POWER

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The N. A. S. E.

IT is difficult for those who were born into this age of power to realize how recent it all is. The Corliss engine was not invented until 1849. Twenty years later, when the Census Bureau began to realize that the power resources of the nation were a factor worth counting, they found 0.6 hp. of steam-made power available for each wage worker in the factories of the nation. By 1914 this had increased to 2.25 hp. of installed steam engines and steam turbines per worker. Of course the number of workers had increased largely in the meantime. The total steam prime-mover installations were 1,215,000 hp. in 1869 and 15,682,000 in 1914. The recent census has not been digested sufficiently to give the later values. These figures do not include water powers, internal-combustion engines, central stations, or power plants in hotels, office and public buildings, department stores, or in anything except factories.

Great as this increase has been, it does not begin to tell the whole story, for the power plant, extremely simple at the time that the first data were collected, has developed great complexity and individual capacity. The engineer who formerly had to take care of a few simple boilers operating at low pressures and moderate capacities, furnishing steam to the simplest kind of slow-running small-powered engines, has now to deal with speeds and pressures and temperatures and capacities that would have staggered his predecessor. The steam turbine and the internal-combustion engine, electricity and refrigeration have been added to his charges, the automatic stoker has jogged the boiler out of its moderate gait, and the high cost of fuel has magnified the importance of efficient operation.

To the man who regards his occupation as more than a job, the responsible charge of a modern power plant offers an opportunity for the exercise of technical knowledge and practical skill of an order comparable to that expected of the heads of important manufacturing departments.

He must be, first of all, a practical mechanic, with a sense, become by long and intimate association with running machinery almost intuitive, of what to do when trouble threatens. He must be considerable of an executive, something of a chemist, a good deal of an electrician and have a working knowledge of heat physics and the laws of structures and of elementary mechanics.

Where have these men come from? The schools have not furnished them. It is only recently that the power plant began to offer opportunities attractive to the technical graduate. They have come up from the ranks, gaining their knowledge of principles and fundamentals by reading and study and mutual consultation. The National Association of Stationary Engineers has been a large and insufficiently appreciated factor in this development, and many of the outstanding figures in power-plant engineering today, filling positions of large remuneration and responsibility owe their start and their progress to the spark of interest kindled, the study habit induced and the confidence and knowledge acquired by their participation in the educational activities of the N. A. S. E.

At this time of social unrest and industrial disorganization an association based upon the better adaptation of its members to fulfill their part in the realization of over-all national efficiency should be the object of special commendation and appreciation.

F. R. Low

New Ford Power Plant at River Rouge

By THOMAS WILSON

Plant featured by large double-ended boilers having 26,470 sq.ft. of steam-making surface and burning simultaneously blast-furnace gas and powdered coal; complete electrical system and unique substation layout; large double-effect evaporating system and centrifugal turbo-blowers having capacity to deliver 40,000 cu.ft. of air per minute against a back pressure of 23 lb.

FROM the preliminary description of the new Ford plant, appearing in the March 1, 1921, issue of *Power*, readers will be familiar with the principal outline of the big power station at River Rouge that is now serving the first complete consolidated blast furnace, foundry and (later) steel mill in the world. The final plan is to produce here all the castings and steel parts used in Ford cars, trucks and Fordson tractors. On a site of approximately 1,500 acres are located the coke ovens, blast furnaces, an immense foundry, a large body plant and other departments fitting into the entire development. The new power station is to supply practically all of the energy required for power and lighting by the entire works, and in addition considerable current will be transmitted at high tension to the Highland Park plant of the company, about ten miles distant.

From the present conception of the works there are to be four blast furnaces, each producing daily 500 tons of iron. Two of these furnaces are complete and one has been in operation for some time. To conform with this general plan the power plant also is to have four electric generating units and there are to be five air compressors each delivering 2,000 cu.ft. of air per min. and five turbo-blowers, one for each blast furnace and an additional unit as a reserve. Each of the blowers has a capacity to deliver 40,000 cu.ft. of air per min. against a pressure of 23 lb. per sq.in. Three of these turbo-blowers, four boilers, each of 26,470 sq.ft. of steam-making surface, and two turbo-generator units designed to deliver 12,500 kw. at 80 per cent power factor have been installed. When the plant is completed according to present plans, there will be eight boilers of the size now installed and two more generating units, but these machines are expected to have a capacity of at least 20,000 kw. each, bringing the total rated capacity up to 65,000 kw. To the aggregate steam-making surface in the eight boilers, 211,760 sq.ft., the electric generating capacity has a ratio of 1 kw. to 3.25 sq.ft. There are other uses for the high-pressure steam; a certain proportion must go to the turbo-blowers, air compressors, evaporator system, and for general process use throughout the south end of the works.

To the engineer, these big boilers are of interest not only from the standpoint of size, as they tower 83 ft. above the ash floor, but also from the fact that they are arranged to burn simultaneously blast-furnace gas and pulverized fuel. The method of controlling the feed of these two fuels and the general control of the boiler are of exceptional interest. Then there is the pulverizing plant, and as operation ranging from 250 to 400 per cent of rating is anticipated, an evaporative plant has been installed having capacity to supply about 25 per cent of the boiler feed. In the early stages of the plant at least this amount of make-up will be required, as much of the process steam is not returned to the boiler room. Details of these interesting features, however, will be reserved for future articles, as the purpose of the present description is to give a general outline of the entire plant.

Fig. 3 is a general view of the exterior of the power house and Fig. 2 shows the layout of the boilers, turbo-generators and centrifugal blowers. The construction is fireproof, the building being made of concrete, steel and brick. The overall plan measurements are 326 ft. 6 in. wide by 220 ft. long, with space for a 50 per cent

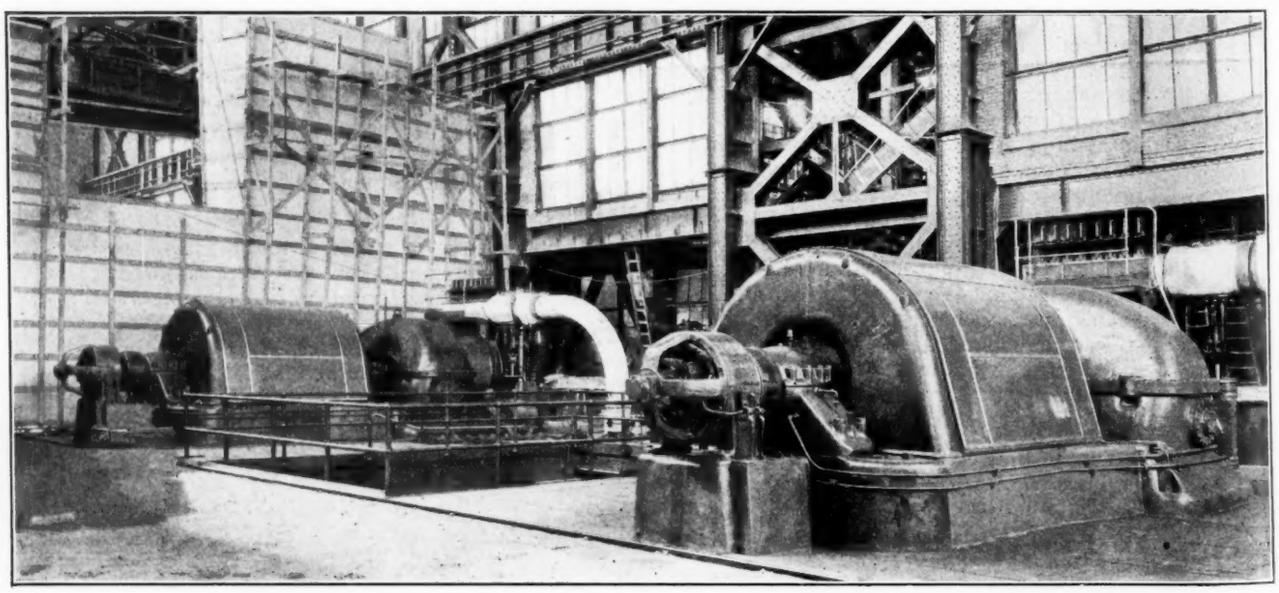


FIG. 1. THE TWO 12,500-KW. TURBO-GENERATING UNITS NOW INSTALLED

increase. In the foreground is the switch house with a frontage of 176 ft. and a depth of 47 ft. Next toward the rear is the turbo-generator room, with a length of 220 ft. and a width of 69 ft. The central portion of the building, separated by a court on either side from the rest of the structure, houses the boilers. It has a width of 117 ft. and towers above the other structures to a height of 120 ft. from the ground floor. Above this section are the steel stacks serving the four boilers now installed. There is a stack for each boiler, 11 ft. in diameter, rising nearly 200 ft. above the roof and 327 ft. above the ground-floor level. These stacks are supported on the upper steel structure of the boiler house, the regular building columns having been designed to take the weight. Behind the boiler house at grade level is the turbo-blower room and on the floor above is the evaporative system and the air compressors. Still farther back is the coal pulverizing plant, which is housed in a separate building, and connected to the boiler room by means of the bridge appearing in the background of Fig. 3. The piping at the right supported from grade by drop legs conveys the blast furnace gas to the boilers. As the boilers, which are to supply steam at 225 lb. pressure and 200 deg. of superheat, giving a final steam temperature of 605 deg., are to be left to a subsequent article, also the auxiliary equipment such as the pulverizing plant and the evaporative system, the turbo-generators shown in Fig. 1 will be considered. Fig. 4 shows the condenser and auxiliaries and Fig. 5 the general arrangement of the two units. The turbines are of standard design exhausting into surface condensers which have a capacity to condense 138,000 lb. of steam per hour with 23,500 gal. per min. of circulating water at 70 deg. F. while maintaining a vacuum of 1½ in. absolute. Each condenser contains 22,000 sq.ft. of cooling surface made up of 1-in. seamless drawn brass tubes 20 ft. 3 in. long. The baffling is arranged for two passes of the circulating water offering a friction head of 13.5 feet.

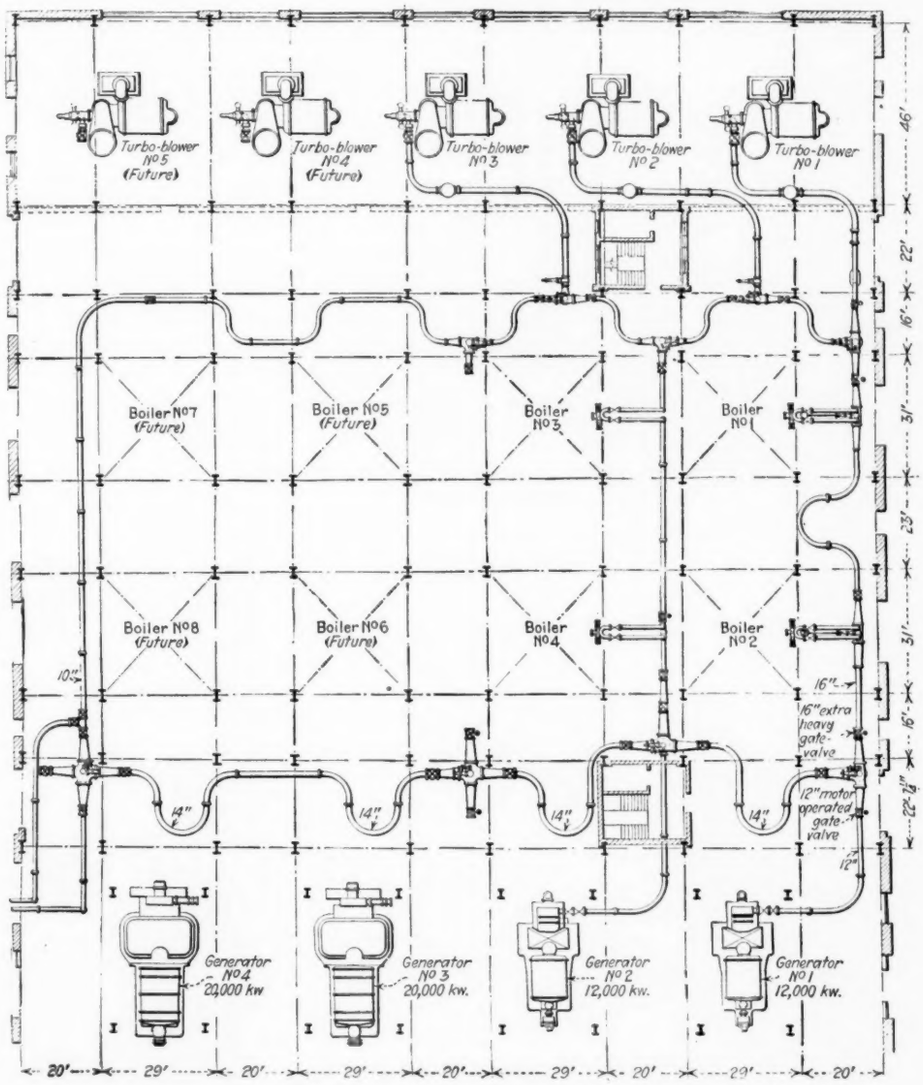


FIG. 2. LAYOUT OF BOILER, TURBINE AND BLOWER ROOMS

The figures show that 1.76 square feet of condenser cooling surface is provided per kilowatt of generator rating; that each square foot of this surface has a maximum capacity to condense 6.27 lb. of steam and that the ratio of cooling water per pound of steam is approximately 83 to 1. The weight of the condenser empty is 130,000 lb. It is placed within the reinforced-concrete foundation, which supports the turbo-generator, and which is doweled to the concrete mat under the building and rises 30 ft. to the turbine-room floor. The condenser rests on four short reinforced-concrete columns tied into the main foundation, which are supported latterly by horizontal concrete beams tying them together. The condenser is bolted to the columns and a copper expansion joint supplies the flexibility necessary in the connection between the turbine and the condenser.

Three radojets of the two-stage type are provided to remove the air. One, two or three of these units may be used, depending upon the load, as all three are connected in parallel and may be turned on as needed. As indicated in Fig. 5, the hot well pumps are in duplicate, and each pump has a maximum capacity to handle 525 gal. per min., although the normal requirement when condensing 138,000 lb. of steam is 278 gal. per min. The pumps are driven by 20-hp. direct-current motors. Following the general plan of providing reserve capacity to insure continuity of service, the circulating pumps also are in duplicate. Each has a capacity of 14,000 gal. per min. at a speed of 515 r.p.m. and, as in the case of the hot-well pump, is driven by a variable-

speed direct-current motor rated at 150 hp. With a single pump operating, 50 lb. of water per pound of steam condensed will be supplied, and with the two pumps in parallel, the quantity may be increased to double this ratio.

Circulating water for the turbo-generator and centrifugal blower condensers, the coke ovens' blast furnace cooling water and all mill water is drawn from the

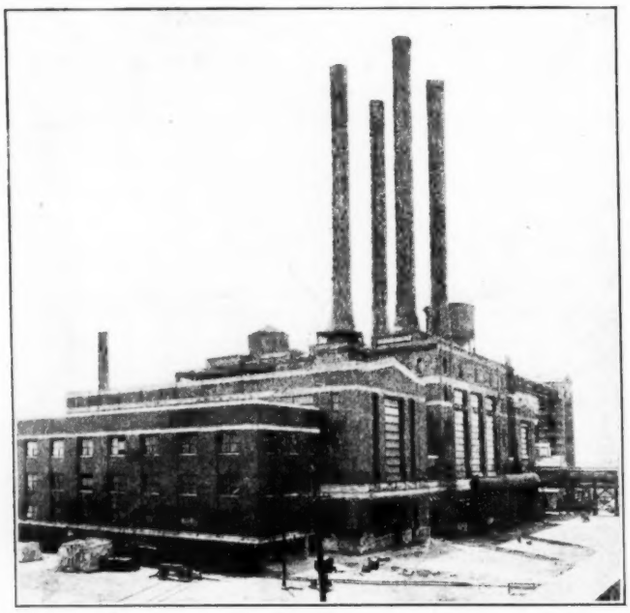


FIG. 3. EXTERIOR OF THE NEW FORD POWER PLANT AT RIVER ROUGE

end of the slip serving the plant, through a completely equipped screen house. The building has been laid out for eight screens measuring 21 ft. between sprocket centers, each having a capacity of 25,000 gal. per min. when the water is at the 12-ft. level and is flowing at a velocity of 1½ ft. per sec. Only three screens are installed at present and each is driven by a constant-speed induction motor. The screens are arranged along the longitudinal center line of the building, each in a separate compartment. On either side is a sluice gate. With this arrangement any one screen compartment can be cut off and pumped out if it is desired to work upon the screen. The eight intake gates are lined up at one side of the building and the outlet gates at the other side, each row of gates being controlled from a single motor-driven jackshaft with a clutch connection to each gate.

From the screen house the water is conducted to the station through a 12-ft. concrete tunnel splitting into two branches as it reaches the plant, one branch passing under the turbo-blower house and the other under the condensers serving the turbo-generators. Corresponding discharge tunnels from these two locations combine and discharge downstream from the inlets. This tunnel also takes care of storm water and all drainage except sanitary sewage. The boiler make-up water which passes through the evaporator plant is also being taken from the river through the intake tunnel.

The switch house will accommodate switching equipment for four generating units and can be extended to take care of two more, or a total of six. Each of the two generating units already in operation will deliver at full load 12,500 kw. at 80 per cent power factor. Three-phase 60-cycle current will be delivered at 4,600 volts. These generators are connected into a double set of buses through oil circuit-breakers as indicated in the single-line electrical diagram, Fig. 6. The bus sections may be connected solidly together or through reactors. Each bus section is tapped by twelve feeders with a maximum rating of 3,000 kva. per feeder. The load is carried through oil circuit-breakers and current-limiting reactors into 450,000 circ.mil. lead-covered cables which form a radial underground distribution system to substations located at various load centers throughout the works. An aluminum cell lightning arrester is tapped into each feeder between the reactor and the cable pot head.

All oil switches, field circuit-breakers, exciter rheostats, governor motors, etc., are remotely controlled from a main bench board on the third floor of the switch house. Back of the bench board is a double vertical board on which are mounted all indicating and recording instruments and relays. Both bench and vertical boards are built in concentric arcs so that from one central position the operator can observe all the instruments and, by turning about, he has a view of the entire generator floor.

The disconnect switches are manually operated by a gang mechanism which simultaneously operates all the disconnects for a given position. The handle of this mechanism is locked in the closed position by an electric latch, which is released by the opening of the main oil switch. This prevents the disastrous mistake of opening disconnects under load. Signal lamps at the disconnect handle indicate the position (open or closed)

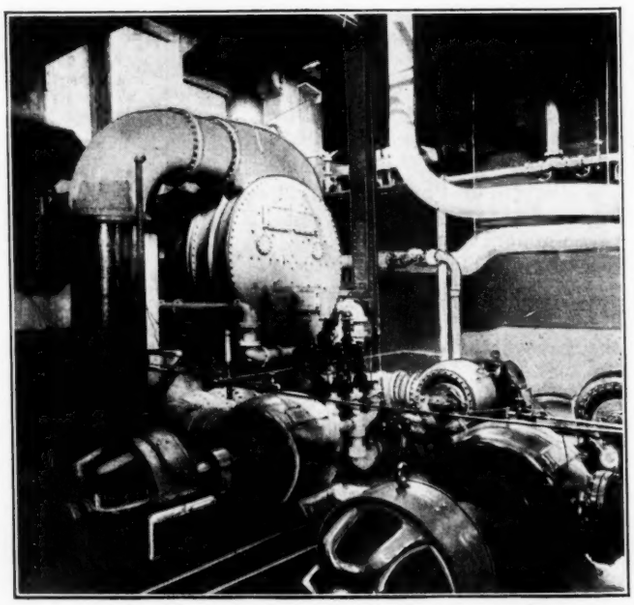


FIG. 4. CONDENSER AND AUXILIARIES SERVING GENERATING UNIT

of the oil switch, and similarly signal lamps at the oil switch indicate the position of the disconnects. Both those systems of signal lamps are duplicated at the bench board where the operator observes the operation of both oil and disconnect switches.

Each turbo-generator is equipped with a direct-connected 250-volt exciter. An auxiliary source of supply for excitation is provided by a three-unit set consisting

of a 150-kw. direct-current generator, driven by a 4,600-volt synchronous motor and a high-pressure steam turbine. A similar set will be added when units 5 and 6 are installed, so that two of the direct-connected exciters can be out of commission, simultaneously.

A small storage battery and charging set have been installed for providing the direct-current power necessary for the remote-control, electrically operated equipment. Emergency lighting circuits throughout the power house are energized from the battery by means of a low voltage relay, which operates in case the normal 110-220-volt alternating-current lighting supply fails. This battery will not be used for auxiliary excitation service.

All the motor applications in the power house have been divided into two classes. Constant-speed motors larger than 100 hp. are 4,600-volt, three-phase, some synchronous and some induction. All other motors are 250-volt direct-current. Two substations within the power house proper provide this power.

One of these substations, designated as No. 5, contains two 1,500-kw. motor-generator sets and one 500-kw. turbine-driven non-condensing unit delivering 250-volt direct-current power through motor-operated circuit-breakers to a common 250-volt bus, from which 1,000,000 cir.mil. cables carry the power to the various motor loads. Each heater is protected by a 1,200-amp. double-pole circuit-breaker.

Substation No. 6, the second of the two mentioned previously, contains a bus structure fed by three 4,600-volt power lines, made up for switching compartments serving twenty 4,600-volt motors driving various pumps and compressors. Each motor control panel is installed at the motor and the starting switches are all installed in the substation, where a starting and a running bus are installed. Two auto-transformers supply the starting bus with power at approximately 2,300 volts. All these remote control switches are electrically interlocked to insure proper sequence of operation and to prevent more motors being started at a time than the auto-transformers can safely handle.

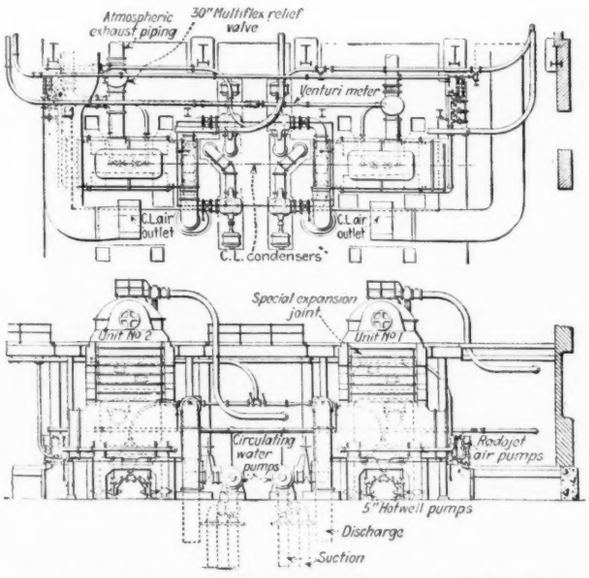


FIG. 5. GENERAL LAYOUT OF THE TWO GENERATING UNITS, CONDENSERS AND AUXILIARIES

In addition to the two substations described, four other stations have been built to date. Fig. 7 is a one-line connection diagram for a typical substation. This illustrates the method of providing each transformer and converting unit with two independent sources of supply for 4,600-volt power. This arrangement avoids the necessity of paralleling the incoming power lines, thereby obtaining the maximum protection from the power line reactor and limiting the short-circuit stresses on the substation equipment to a minimum.

Substation No. 1 contains four 500-kw. motor-generator sets for 250-volt, direct-current power and two

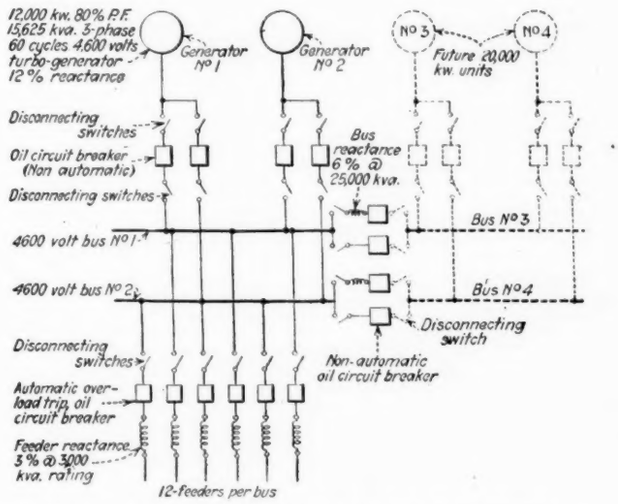

12,000 kw. 80% P.F. 15,625 kva. 3-phase 60 cycles 4,600 volts turbo-generator 12% reactance
Generator No 1
Generator No 2
No 3
No 4
Future 20,000 kw. units
Disconnecting switches
Oil circuit breaker (Non automatic)
Disconnecting switches
Bus reactance 6% @ 25,000 kva.
4600 volt bus No 1
4600 volt bus No 2
Bus No 3
Bus No 4
Disconnecting switch
Non-automatic oil circuit breaker
Disconnecting switches
Automatic overload trip, oil circuit breaker
Feeder reactance 3% @ 3,000 kva. rating
12-feeders per bus

FIG. 6. SINGLE-LINE DIAGRAM OF ELECTRICAL CONNECTIONS

banks of three 500-kva. transformers for 440-volt three-phase power. This station feeds the coke ovens, their coal-handling equipment and the buildings in which the byproducts are handled.

Substation No. 2 contains three 1,500-kw. motor-generator sets for 250-volt direct-current power and one bank of three 500-kva. transformers for 440-volt three-phase power. This station serves four coal and ore unloaders, two ore bridges, transfer cars, skip hoists and the other auxiliaries of the two 500-ton blast furnaces.

Substation No. 3 is situated at the northern end of the property and contains two steam turbo-generators as well as substation equipment. One machine is rated at 2,000 kw. and one at 500 kw., 4,600-volt, three-phase, 60 cycles. There is provision for future installation of one of each of these units. Exhaust steam from these turbines is used for factory heating and their generators are arranged to parallel with power lines from the main power house. The substation contains two 1,500-kw. and one 1,000-kw. motor-generator sets for delivering 250-volt direct-current power and one bank of three 500-kva. transformers for 440-volt three-phase power. Provision has been made for the addition of one more 1,500-kw. motor-generator set and one more bank of 500-kva. transformers. This station serves the factory buildings that were formerly used for the construction of "Eagle" boats.

Substation No. 4, which is not completed, will contain for the present three 1,500-kw. motor-generator sets for 250-volt direct-current power and one bank of three 500-kva. transformers for 440-volt three-phase power. Future plans call for two additional 1,500-kw. motor-generators and an additional bank of three 500-kva. transformers. This substation will serve the foundry

building and will take the load of two future 500-ton blast furnaces.

In the near future a large outdoor substation will be erected at the north end of the plant for the transmission of 30,000 kva. of electrical energy at 25,000 volts to the Highland Park plant, situated about ten miles distant.

The 150-kw. turbine of the three-unit exciter set is used for starting when the station is down or in the winter when its exhaust as well as the exhaust from

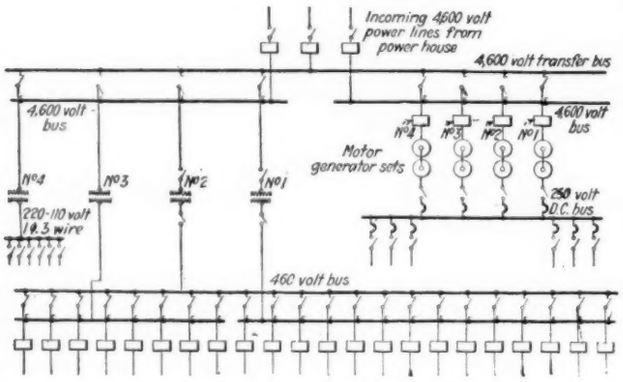


FIG. 7. TYPICAL SUBSTATION LAYOUT

the 500-kw. house turbine in substation No. 5 may be used for heating certain portions of the power plant and other buildings in the immediate vicinity.

Although at present the main generating units are cooled by air drawn from the outside by the fans on the generators, and the discharge is into the turbine room, a complete system of air washers is to be installed. Eventually there are to be four washer units each having a capacity of 80,000 cu.ft. of air per minute, cooling it down to within 95 per cent of the wet bulb temperature and taking out 98 per cent of the foreign matter. For the first two units, however, which are smaller than the other two to be installed later, only one washer is to be provided. The washer units are to be placed on the top floor of the switchhouse. Each will have a turbo-vane fan with a maximum capacity of 80,000 cu.ft. per minute against a head of 1¼ in. The intake is arranged so that air may be drawn from the outside through tempering coils to raise the temperature above the freezing point in cold weather or the supply may be drawn from the turbo-generator room and recirculated. Tempering coils are provided also between the washer and the fan to raise the temperature of the air to at least 50 deg. before discharging it to the generators. The fans discharge into a common plenum chamber from which a duct leads to each generator. Dampers are provided in the plenum chamber so that a portion of the air may be discharged directly into the turbine room for cooling during the summer and dampers in the discharge ducts from the generator admit hot air into the turbine room during the colder months. Ordinarily, all of the air is discharged from these ducts into the boiler room from which it is drawn into the furnaces, so that the heat carried away from the generators is utilized. With the arrangement outlined it is anticipated that the turbine room will be maintained at a comfortable temperature in summer and winter and that precipitation of moisture from the ceiling will be eliminated.

One of the interesting departments of the plant is the turbo-blower room, which is laid out for five units to supply air to the blast furnaces. At the present three machines have been installed, each having a capacity to deliver 40,000 cu.ft. of air per minute against a pressure of 23 lb. per sq.in. The blowers are of the latest centrifugal type, each being driven by a 3,000-hp. 40-stage steam turbine taking steam at 200 lb. pressure and 200 deg. superheat at the throttle. Control is effected by a governor that corrects for temperature and humidity and insures a constant volume of air irrespective of pressure. These units have been in

PRINCIPAL EQUIPMENT OF RIVER ROUGE PLANT, NOW INSTALLED

No.	Equipment	Kind	Size	Use	Operating Conditions	Maker
4	Boilers	Double-ended water tube	26,470 sq. ft.	Generate steam	240 lb., 200 deg. superheat.	George T. Ladd Co.
8	Superheaters		1,500 sq.ft.	Two per boiler	200 deg. superheat	The Superheater Co.
48	Feeders	Screw, motor dr.		12 per boiler	Electrically controlled	Combustion Eng. Corp.
1	Evaporator system	Two-effect	150,000 lb. per hr.	Furnish make-up		Griscom-Russell Co.
2	Heaters	Open	600,000 lb. per hr.	Heat feed water	Exhaust steam	Hoppes Mfg. Co.
1	Pump	4-stage cent.	1,500 g.p.m., 700 ft. hd.	Boiler feed	Driven by 350-hp. G. E. turbine, 1,750 r.p.m.	Manistee Iron Works
2	Pumps	8-stage cent.	1,000 g.p.m., 700 ft. hd.	Boiler feed	Driven by 250-hp. Westinghouse d.c. motor, 1,150 r.p.m.	Manistee Iron Works
2	Pumps	Centrifugal	1,000 g.p.m., 85 ft. hd.	Hot well	Dr. by 30-hp. G.E. turbine	Manistee Iron Works
1	Pump	Centrifugal	1,500 g.p.m., 85 ft. hd.	Hot well	Dr. by 50-hp. G. E. synchronous motor	Manistee Iron Works
3	Pumps	Centrifugal	3,600 g.p.m., 150 ft. hd.	Service	Dr. by 150 hp. Westinghouse syn. motor	Allis-Chalmers Co.
2	Air compressors	Hor.-vert.	2,000 cu.ft. per min.	Compressed air for gen. ser.	125 lb. air, dr. by 450-hp. G. E. syn. motor	Sullivan Machinery Co.
3	Turbo-blowers	Centrifugal	40,000 cu.ft. per min.	Air to blast furnaces	Steam tur. driven, 23 lb. air	General Electric Co.
3	Condensers	Vertical surface	6,300 sq. ft.	Serve blower turbines	C.H.Wheeler Radojet air pump and mot.-dr. auxil.	Wheeler Condenser & Eng. Co.
2	Turbo-Generators	Alternating-cur.	12,500 kw.	Main generating units	4,600 volt, three-phase, 60-cycle, 1,800 r.p.m.	General Electric Co.
2	Condensers	Surface	22,000 sq.ft.	Serve main. gen. units	Radojet air pumps and motor-driven auxiliaries	C. H. Wheeler Mfg. Co.
3	Screens	Traveling	25 g.p.m.	Condenser circ. water	Chain-dr. by 5-hp. Induction motor with reducer	Chain Belt Co.
1	Exciter set	Three unit	150 kw.	Auxiliary excitation	Dr. by 225-hp. Terry turbine and synchronous motor	General Electric Co.
1	Turbo-generator	Non-cond., d.c.	500 kw.	House service	Geared unit, 220 volt, d.c.	Westinghouse Elec. & Mfg. Co.
2	Motor-generators		1,500 kw.	House service	Syn. motor dr., 220 v., d.c.	Westinghouse Elec. & Mfg. Co.
3	Fans	Turbo-vane	45,000 cu.ft. per min.	Air to burn blast fur. gas	D. C. motor drive	B. F. Sturtevant Co.
1	Conveyor	Apron	102 ft. centers	Delivers coal to bunker in pulv. house	Motor driven	Hyel & Patterson Co.
12	Conveyors	Screw	Four 14-in., eight 16-in.	Coal from pulverizers to boiler house bunker	Ind. motor, silent chain dr.	H. W. Caldwell & Son Co.
4	Conveyors	Bucket	40 tons per hr.	Coal tower of pulv. house	Induction motor drive	H. W. Caldwell & Son Co.
4	Mills	Six-roll, low side	6 tons per hr.	Pulverize coal	Air separation type	Raymond Bros. Impact Pul. Co.
4	Exhausters			Draw coal from pulv. mills	Induction motor drive	Raymond Bros. Impact Pul. Co.
1	Crane	Traveling	75 tons	Turbine room		Milwaukee Electric Co.
2	Cranes	Traveling	One 50 tons / One 10 tons	Turbo blower room / Evaporator room		Pawling & Harnischfeger

Vulcan 12 element soot blowers; Crane stop and check valves; Corliss steam traps; Bailey steam flow meters; Ellison differential draft gages; Richardson-Phenix oil filters; Copes feed water regulators.

operation for over a year and have given excellent service.

Vertical condensers of the two-pass type serve the turbines. These condensers contain 6,300 sq.ft. of surface and are so arranged that either half can be cut out for cleaning while the other half remains in operation. For auxiliaries, duplicate condensate pumps have been provided. There are three Radojet air pumps connected in parallel, so that one or all may be used, although normally only one is required. Circulating water is supplied by a single-stage centrifugal pump driven by a direct-current 75-hp. motor. The cooling water is taken from the intake tunnel previously mentioned and discharged to the return tunnel.

Air for the blowers is drawn through inlet screens and after being compressed to the desired pressure is delivered into mains leading to stoves adjacent to the furnaces. The air is heated in these stoves and is then passed on to the blast furnaces. The gases resulting from the chemical reactions in the furnaces are taken off at the top and after passing through a series of cleaners are burned in the stoves for preheating the furnace air or forced through an 8-ft. main to the boiler room to be used as a fuel for steam generation. In the next article, which is to deal with the boiler

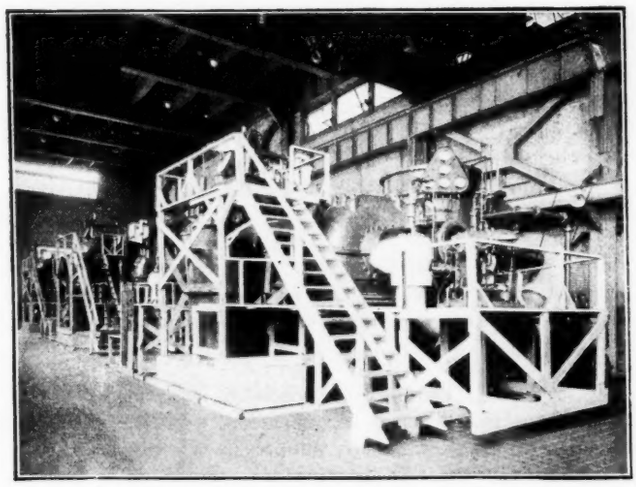


FIG. 8. THE THREE TURBO-BLOWERS NOW IN OPERATION WITH TEMPORARY PLATFORMS

installation, the delivery of the gas to the boiler furnaces will be considered.

In lubricating the blower units as well as the turbo-generators, a certain proportion of the oil is circulated continuously; the overflow from the reservoir in the turbine base passes through filters in the basement and is then pumped back to the reservoir, the amount being pumped into the reservoir determining the overflow. There are two filter installations in each department mentioned, the oil overflow passing into a common main delivering to either or both of the filters as required.

On the floor above the turbo-blowers are the evaporative system and the air compressors, installed to supply air at 125-lb. pressure to the foundry, coke plant and for other uses. Two of the five units that will be eventually installed are now in place. Each has a capacity to deliver 2,000 cu.ft. of free air per minute. The machines are of the two-stage horizontal-vertical type, driven by 450-hp. synchronous motors. The cylinders are water-cooled and the usual intercooler is provided between the stages.

For the general design and construction of the mechanical end of the plant credit is due W. B. Mayo, chief construction engineer and his assistant, C. S. Turner, who was in direct charge of the work. The

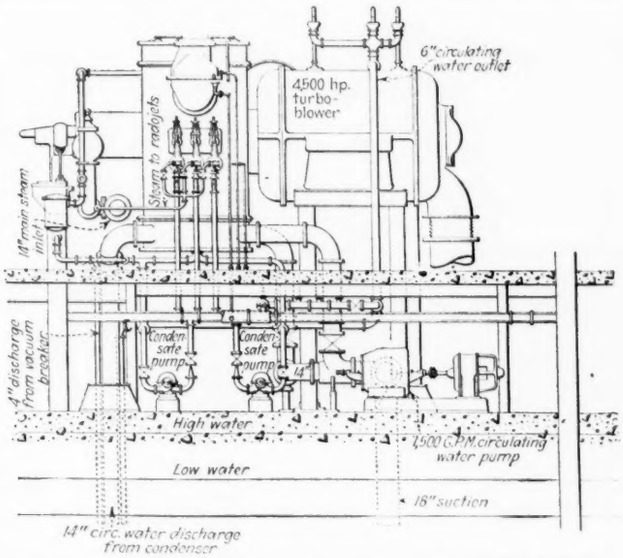


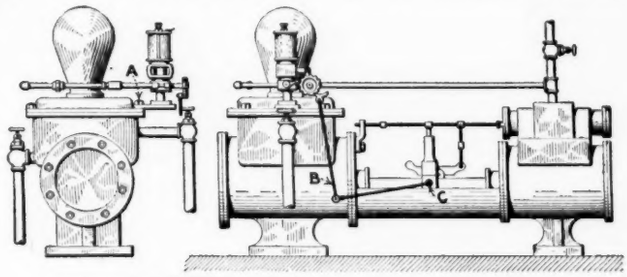
FIG. 9. ENTIRE TURBO-BLOWER UNIT INSTALLED ON STRUCTURAL STEEL FOUNDATION

entire electrical installation at River Rouge has been designed and installed under the supervision of Fred Allison, who has directed the electrical policies of the Ford Motor Co. since its early days.

Pump Lubrication Improved

BY W. H. WAKEMAN

A direct-acting single steam pump used as a boiler feeder required an excessive amount of cylinder oil, and even then it gave evidence of lack of lubrication. Oil was forced into the steam chest at irregular intervals by a hand pump, hence in a few minutes after the operation the valve and piston were without lubrication.



FORCED-FEED LUBRICATOR DISPLACES HAND LUBRICATION

A force-feed oil pump that was taken out of service several years ago was connected to the pump, as shown. Washers were removed from the water cap-bolts at *A* and a piece of thin flat iron 4 x 10 in., with holes properly drilled was substituted to support the oil pump.

A long rod *B* was used to reduce the motion of the ratchet above it. A bolt through the crosshead at *C* was removed and replaced by a much longer one to bring the connecting rod into line with *B*. This oil pump operates satisfactorily and the consumption of oil is reduced 60 per cent. The reason for this oil reduction is due to doing away with an intermittent feed and installing a steady feed of oil at a low rate.

Safety Precautions in the Operation of Large Turbines

Practical Pointers on Avoiding Turbine Injury Due to Spindle Deflection, Blade Rub, Dummy Rub and Other Causes, Together with Rules for Starting and Stopping Large Turbines

TO THE DESIGNER of large steam turbines no more serious problem presents itself than the prevention of vibration in the rotating element, for it is in this that most turbine troubles have their origin. The operating engineer's principal duty is to so maintain and operate this type of prime mover that the chief causes of vibration are prevented.

The dangers attending any interference with the revolving element of a turbine will be better appreciated when we consider that it is a revolving mass having a peripheral speed of 800 to 1,000 ft. per second and weighing from 30 to 40 tons, while the time from first indications of increasing vibration to a serious injury of the unit may be less than twenty seconds.

Vibrations may be primary or secondary in their character. Some of the most common causes of primary vibration are: Faulty shop work or erection; deflection of spindle; excess bearing clearance; improper fit of bearing in housing; admitting air through glands.

Secondary vibrations may be caused by: Rubbing or loss of blades; local heating due to rubbing of packing or sealing rings; wedging of spindle by fused metal; distortion of cylinder casing by expansion of steam pipes; lack of rigidity in the rotor due to improper fitting of component parts; warping of blade rings, etc.

The first primary cause of vibration—faulty shop work or erection—is a matter for the builders to correct. They will be found ready and anxious to correct any defects in this direction, but the engineer should be so educated in the operation and inspection of the turbine that he can locate any defects in the new machine.

Deflection of Spindle—This is the most frequent cause of vibration, as it may present itself every time the machine is brought to speed. It is usually caused by the sagging or deflection of the shaft between its bearings during periods of rest, or by a leaking throttle valve which allows the higher-temperature steam to occupy the upper part of the casing, thereby heating the spindle unequally and causing it to warp. The remedy for these troubles is to turn the spindle to new positions at regular intervals during the off-load periods. In starting the machine the spindle should be rotated as quickly as possible and the steam shut off immediately after it begins to turn. The machine is then sounded and the exposed section of the spindle is inspected for deflection. If everything seems to be in good order, the steam is again turned on and the spindle brought to about 25 per cent speed, being allowed to revolve at this rate for 15 or 20 minutes, which will usually insure smooth running. It is then brought up to operating speed.

If unusual vibration develops, the steam should be shut off immediately and the spindle brought to low speed until no deflection is notice, when it is to be brought back to speed again. Nothing but emergency conditions should justify applying load to a turbine when the spindle shows indications of unusual vibrations, and under these conditions good judgment is necessary in deciding when the danger point has been reached and the shutting down of the machine is advisable.

Excess Bearing Clearance—The usual practice is to allow a total clearance of about 1½ thousandths for each inch of shaft diameter. On this basis if the shaft is concentric with the bearing, a 10-in. shaft will have a radial clearance of 7½ thousandths. This clearance is necessary to admit a sufficient volume of oil under pressure to support and flush the shaft. If this clearance is increased to the point where gyration of the shaft is produced, there are two vibrations set up, one due to the lack of perfect mechanical balance and the other to the gyration. These vibrations tend to oppose each other until a speed is reached when they are in synchronism. This speed is known as the critical speed of the machine. It usually occurs about 25 per cent below the operating speed. It is obvious that in bringing machines to speed, this point should be passed as quickly as possible.

Improper Fit of Bearings in Housing—When the bearing shells are not closely fitted to the structure that supports them, vibrations will be set up which may produce trouble that is described under other headings.

Cold Air Cause of Distortion

Admitting Air Through Glands—The practice of having the dry vacuum pump in operation, with the suction pipe open to the condenser, should be discouraged, as the cool air, in passing through the glands on its way to the condenser, cools the lower part of the spindle and casing, producing a possible distortion of the parts which may result in vibration and rubbing when the spindle starts to rotate.

Blade Rubs—This is the most common trouble in turbines with small clearances and is of two classes. One, when the revolving blades rub the stationary element, is known as a cylinder rub. The other, when the stationary blades rub the shaft, is known as a spindle rub. In the former case the greater mass of metal allows a quicker dissipation of the suddenly generated heat and there is less chance of trouble than in the case of a spindle rub where a high local temperature is generated in the shaft, resulting in shaft deflection. In either case, if the cause of the rubbing is not removed, or if the turbine is kept in operation because the rubs are not detected, the trouble may become cumulative in its character and blades be dislodged and wedged between the two elements. This throws the shaft out of line and produces vibration which may quickly lead to serious trouble.

It is obvious that no pains should be spared in so setting the rotor and stator in relation to each other that a constant and uniform clearance can be main-

tained. The following procedure is usually observed: After the spindle has been assembled it is run at its maximum speed for the purpose of "stretching" the blades by centrifugal force, so that when the machine is received at the plant where it is to operate it is ready for erection. After the necessary aligning, leveling, etc., the spindle is set in the bearings, covers bolted down, and made ready for operation when "cold clearances" are taken. The latter operation consists of setting the spindle so that it will have the desired clearance between the tips of the blades and the cylinder.

From Fig. 1 it will be seen that the shaft is carried by a cylindrical bearing, having inserted in its circumference four pads set 90 deg. apart. These pads are closely fitted in the housing (not shown in the figure) and are secured to the bearing shell by capscrews. Under each pad are fitted liners of different thicknesses aggregating approximately $\frac{1}{4}$ in. By taking liners from the upper pad and inserting them in the lower one, the shaft is elevated a corresponding amount. The spindle is then turned by hand, and if contact is not secured, the operation is repeated until a "rub" is produced between the blade tips and the top of the cylinder barrel. The operation is then reversed until a rub is located in the bottom of the cylinder. The liners are then divided so as to set the spindle in the vertical center. The work is next carried to the side pads, the spindle being moved to its extreme right and left positions and returned to a point midway between these extremes. It is then

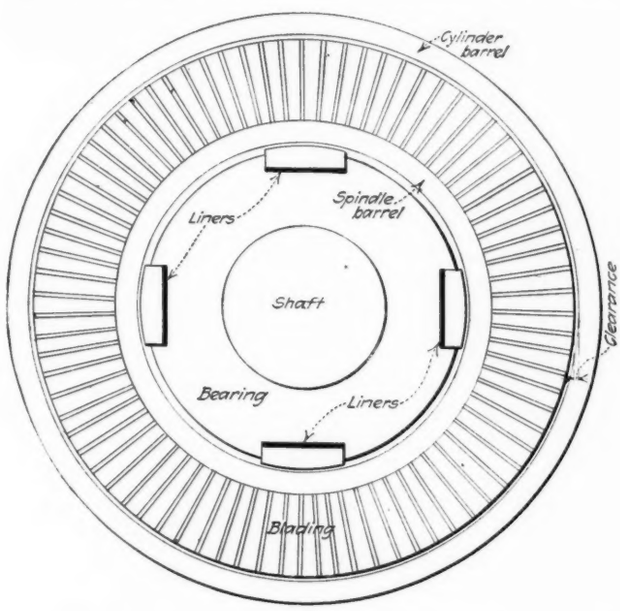


FIG. 1. SKETCH OF BEARING SHELL, SHOWING PADS AND LINERS FOR CENTERING TURBINE ROTOR

central. If the clearances secured are considered adequate for safe and efficient operation, the turbine is heated with steam and the foregoing operation repeated while hot. The hot clearances indicate the changes produced by high temperature and give the clearances that may be expected when the turbine is in operation. The spindle is then set midway between the hot and cold clearance positions. In the larger machines allowance is made for the "rise" of the top casing due to temperature and raising of the shaft by the oil film in bearings.

To guard against spindle rubbing, the cylinder blades are made shorter than the spindle blades, so that in taking clearances the spindle blading only is considered.

To prevent the escape of steam from the inlet chamber to the exhaust, grooves are cut in the periphery of the balancing pistons into which are fitted projecting strips of metal which alternate with corresponding cylinder strips known as dummies. The greatest distance that the spindle can move in a horizontal direction before the dummies came in contact is known as the end

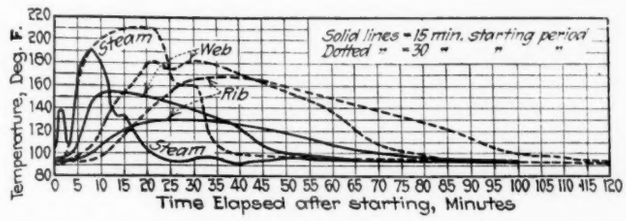


FIG. 2. EFFECT OF WARMING-UP PERIOD ON TEMPERATURE AFTER STARTING

It was found that a 15-minute warming-up period brought the turbine more nearly to operating temperatures than a 30-minute period.

travel of the machine. As this distance is less than that necessary to bring the stationary and moving blades in contact with each other, it serves as a protection in this direction. The principal function of the thrust bearing is the setting of the spindle so as to insure the minimum leakage of steam past the dummies and a clearance sufficient for safe operation. It is so constructed that, with a worm and gear, it can be used to force the spindle forward until the backs of the dummies rub and then in the opposite direction until they touch in front. The thrust bearing is so adjusted that the dummy faces are kept 0.010 in. apart and locked in this position. Occasional checking of the end travel serves as a guide in locating any changes in the dummies, distortion of balancing pistons, casings, etc.

Local Heating Due to Dummy Rub—When from distortion, uneven expansion or other causes, the dummies are brought in contact with each other, a sudden high temperature is generated which may fuse the parts so heated. The usual result of heating a ring is to expand it, but in the local heating of the dummy rings the effect is the opposite of this, for when the dummies rub, the stationary ring closes in on the revolving shaft and produces a wedging action due to the fused metal building up between the shaft and ring. This forces the shaft out of line, producing destructive vibrations or whippings of the shaft that may lead to loss of blades or even more serious results.

Distortion of Cylinder Casings by Steam Pipes—It frequently occurs in connecting steam pipes to steam chests of turbines, that no allowance has been made for the movement due to the expansions of the steam line, the result being that strains due to this expansion are transferred to the cylinder casing and produce a condition dangerous to operation. Before the steam pipe is bolted to the steam chest, its position should be noted. It should then be heated to its operating temperature and the amount of movement measured. Midway between these two positions should be the point for connecting the pipe to the turbine.

Lack of Rigidity in Spindle—It may have happened in making the pressed fits of the barrels in the assembling of the spindle that insufficient pressure was used so that eventually a slight movement of the parts

occurs. In such cases it is not possible to discover the trouble without dismantling the rotor.

Heating Turbine Before Applying Load—The length of time a rotor should be allowed to rotate before bringing it to full speed is a subject worthy of considerable thought and study. An extended heating period may bring results contrary to those desired, for it is possible to heat the parts to a point so high above the operating temperature that a rapid contraction is produced when the machine assumes load conditions. In the curves of Fig. 2 the continuous lines represent the steam temperature of the exhaust space, the ribs of the exhaust nozzle, and the web between these ribs during a heating up period of 15 minutes. The broken lines represent the temperatures of the same locations during a 30-minute warming. Considering the exhaust temperature under load conditions as 90 deg. F., it will be seen that in the 15-minute period the temperatures were held at a lower point than those of the 30-minute period, and in addition there was a closer relation between the temperatures of the steam rib and web with a better return to operating temperature. Under these conditions, if the spindle were thoroughly heated and no deflection present, it would seem that the shorter period would produce less distortion and consequently be the safer and more economical method.

In consideration of the foregoing, the starting and stopping of a large turbine should be done as follows:

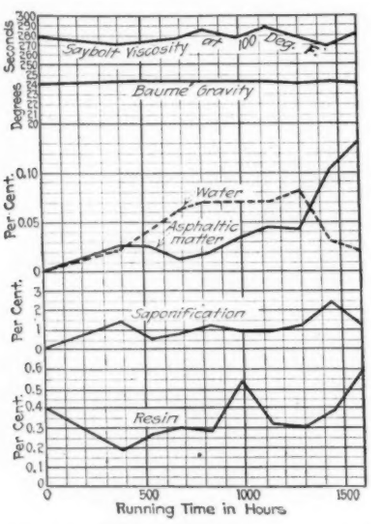


FIG. 3. TEST SHOWING PHYSICAL AND CHEMICAL CHANGES IN OIL DURING 1,600 HOURS OF OPERATION

1. Start the auxiliary oil pump, bringing oil to the operating pressure.

2. If the throttle valves are so constructed that they do not respond to the overspeed trip unless fully opened, test the automatics by tripping the overspeed device, noting carefully any tendency to stick or act sluggishly.

3. Bring the circulating pump to speed with full capacity through the condenser.

4. Operate the dry vacuum pump at quarter speed with the dry air line closed to condenser.

5. Have the hotwell pump running with suction and discharge valves open as soon as sufficient water is in the hotwell to seal the pump.

6. Have the field current on generator with some positive indicator denoting the fact.

7. Have the seals turned on the glands.

8. Start the rotor turning and shut steam off immediately by closing the throttle by hand, if it will not respond to the overspeed trip. However, if all valves respond to the overspeed when throttles are a short distance off the seat, then trip by the overspeed (which will serve as a test of the automatic) instead of proceeding as in 2. The turbine is then sounded for rubs or any indications of unusual conditions. If nothing is wrong, steam is again turned on and the exposed portion of the shaft inspected for deflection. A speed of

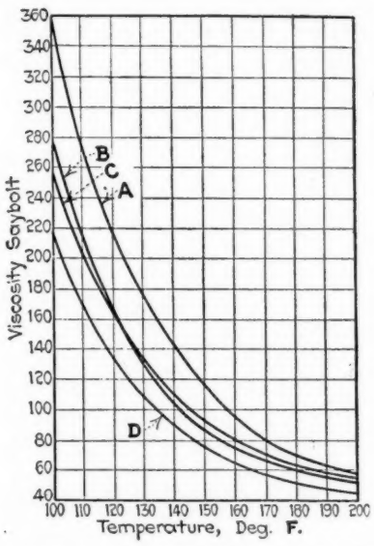


FIG. 4. VARIATION OF VISCOSITY WITH TEMPERATURE IN THE CASE OF FOUR TYPICAL TURBINE OILS

175 to 200 r.p.m. is attained, and the rotor permitted to revolve at this speed for fifteen or twenty minutes with about ten inches of vacuum on the condenser. If no vibrations develop, the rotor can be brought to speed and load applied taking about fifteen or twenty minutes. Close the vacuum breaker when the turbine is brought to speed. This permits a full vacuum when load is built up. The throttle valve is opened wide when load is applied and the auxiliary oil pump is cut down to as low a speed as will keep it moving in case it should be needed in a hurry.

Rules for Shutting Down

1. When the time for shutting down can be anticipated, the auxiliary oil pump is to be started (if not automatically controlled) five minutes before this time.

2. When load is thrown off the engine, the engineer will close all valves and open the vacuum breaker by tripping the overspeed device. This will test the automatics under pressure conditions. Any tendency of a valve to stick should receive immediate attention.

3. Air and hotwell pumps are then shut down, and when the pressure in the condenser rises to atmospheric, the gland seals are to be shut off. When the spindle comes to rest the auxiliary oil pump is to be shut down and the field current shut off. The turbine is to be sounded when slowing down and unusual sounds noted.

Lubrication of Turbines

The lubrication requirements of a turbine are so different from those of a reciprocating engine that the engineers and oil refiners have had problems in the oiling of large units which are not fully solved today.

The turbine shaft cannot be permitted to touch the bearing metal while under load. The shaft speed of 8,000 ft. per min. and pressure of 50 lb. per sq.in. would almost instantly wipe out the babbitt metal and so lower the revolving element that serious trouble would quickly result. To guard against this possible trouble, oil is supplied to the bearings under a pressure of 6 or 8 lb. and carried by the surface friction of the shaft to a pressure sufficient to float the rotor's weight of 15 to 17 tons per bearing. Under these conditions the oil is subjected to a combination of impact, pressure and velocity, and when accompanied by a slight percentage of moisture—even as low as 1 per cent—emulsification is produced, which accelerates the oxidization and causes what is erroneously referred to as the "breaking down"

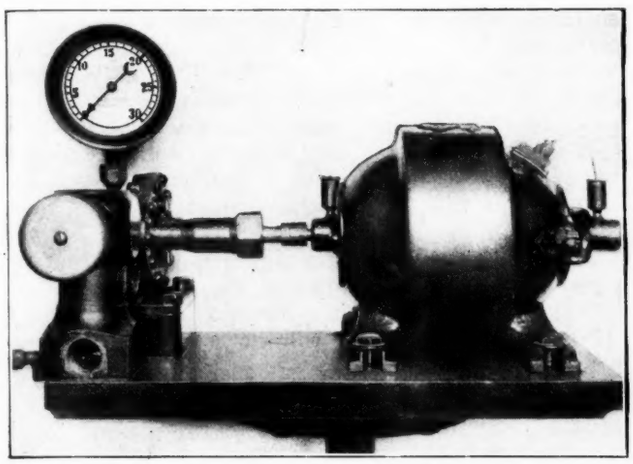


FIG. 5. APPARATUS FOR TESTING TURBINE OILS

of the oil. Under such conditions only a small percentage may be affected if a suitable oil is used so that it is not necessary or advisable to discard the lubricating charge. Proper filtration by any of the different methods will restore the oil to its original value and, in the case of some oils, will increase that value. The loss in filtration is confined to the small percentage affected by oxidation. The continued use of emulsified oil will synthetically produce asphaltic matter and resin and increase the tendency toward saponification. The asphaltic and the resinous matter combine to form an insulating varnish which covers the coils of the cooler, thereby lowering its efficiency and causing oil to be delivered to the bearings at increased temperature. This gradually accelerates the emulsifying conditions and the trouble becomes cumulative.

By referring to the curves of Fig. 3, it will be seen that the viscosity and gravity of the oil remained unchanged during a 1,600-hour test. This was also true of the flash and fire points (which are not shown), proving that the basic characteristics of the oil remain unchanged. This oil, when filtered, was returned to the turbine in better condition than when new.

The foregoing is true whether the oil is from an asphaltic or a paraffine-base crude. Further experiments with oils of different viscosities from the same crude prove that oils of lower viscosity are more suitable for turbine lubrication than those of higher viscosity. Viscosities ranging from 120 to 150 have been found to give the best results. It should be borne in mind that the commercial viscosities refer to oils at 100 deg. F., while the temperature at which the engineer must compare them may be as high as 175 or 180 deg Oils with a difference of 120 in their viscosities at 100 deg. may approach within 10 seconds of each other at the higher bearing temperature. The effect of temperature on viscosity is shown by the curves in Fig. 4, for which four prominent brands of turbine oil were tested. While the foregoing is true, the tendency to emulsify seems to be in proportion to their commercial viscosities, even when oils from the same crude and refined in the same plants are considered.

When troubles with emulsification of turbine oil were first experienced, it was considered an indication of inferior oil, but it is now generally conceded by all interested that, given the proper amount of impact, moisture and velocity, all oils will assume an emulsified condition. Accepting this as being true, it follows that the logical test for a suitable oil for turbine lubrication is the rate at which it demulsifies and separates from the oxidized matter.

To carry on these tests on a turbine in actual operation involves considerable labor, cost and trouble and in extreme cases some liability of damage to the machine. A much better plan is to reproduce the operating conditions in a test machine which is easily constructed from a small gear pump. This is run at a speed that will duplicate the velocity and pressure carried in the turbine. Fig. 5 shows a machine assembled for this purpose, consisting of a gear pump so arranged that a controlled pressure can be carried on the discharge and an electric heater inserted in the base to give a constant temperature. A mixture of six ounces of oil and 5 per cent water is put in the suction chamber and churned for fifteen minutes, after which it is placed in a graduated bottle and kept at a temperature of 150 deg. F. The line of separation is noted every five minutes and the rate of demulsification determined. Oils requiring over ten hours to clear up are considered as being permanently emulsified and not suitable for turbine work. By noting the rise of temperature in the test machine and the rate of demulsification and comparing these results with the temperature and performance of oil in actual operation, a factor can be established which, when applied to any oil tested, will closely approximate what the operating conditions would be if the oil were to be used on the turbine.

Any part of an engine that has been adjusted must be watched closely for a while, and the engineer must be prepared for an emergency. One of the most disagreeable things that can happen is a hot pin or bearing. On a new engine this may come quickly, and not much time can be lost in applying remedies. If the crankpin gets hot, it should be flooded with oil through the center oiler. Should the heating continue, the engine must be slowed down and the wedge backed off. The same thing should be done if the crosshead pin heats unduly. On main and outer bearings the cap bolts should be loosened, the quarter-boxes backed off, and plenty of oil poured on the shaft. Light oil has no lubricating effect on hot surfaces. It is, therefore, of little use on a hot bearing or pin except to carry off some of the heat if used in considerable quantities. To be beneficial, it must be mixed with cylinder oil, but cylinder oil alone is to be preferred. Filtered water mixed with oil may be used for cooling, but never hydrant or well water that contains grit, which would embed itself in the surfaces and quickly ruin them.—*Steam Engine Troubles*, by *H. Hamkins*.

Locating Faults in Direct-Current Armatures—Coils and Windings*

By B. A. BRIGGS

THERE are many forms of armature coils. The simplest is that used on large machines and is a bar made up into a single-turn coil, as in Fig. 1. When an armature is wound with such coils, an open-circuit seldom occurs, since the mechanical strength

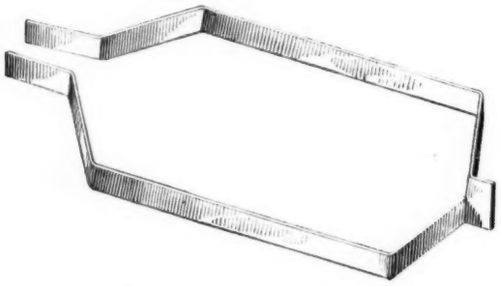


FIG. 1. COIL MADE FROM COPPER BAR

of the winding is such as to reduce the possibility to a minimum. However, high-resistance connections do occur, due to poor soldering to the commutator or to overheating of the coils. In a single parallel-connected winding the two leads of the coil are brought to adjacent commutator bars as in Fig. 2. If the insulation between two bars should fail as at *X*, the coil will form a closed-circuit on itself and the voltage generating in it will cause a current to circulate from *2* to *B*, from *B* back to *3* and across the defect to *2*, thus completing the circuit. The value of the current will depend upon the resistance of the defect in the insulation between the two bars. When these defects first occur, they are usually of comparatively high resistance and the current through them is correspondingly low. This small current has two effects—that is, to heat the fault and also to further carbonize the insulation—both of which tend to reduce the resistance and increase the current. As a result the insulation fails to such an extent and the current increases to a value where the heating becomes so severe at the defect as to cause the two bars to be forced up higher than the others. Cases are on record where the bars came up so high as to destroy the brushes before the machines could be shut down, and, in one case to the writer's knowledge, the brushes knocked bars out of the commutator. Undoubtedly, in this instance the commutator was of poor construction.

The winding shown in the figure is part of that for a generator, and the arrows on the coils indicate the direction of voltage, for the direction of the armature shown by arrow *G*. It will be noted that current through the armature winding is from the — brush to *A* to *2*, *B*, *3*, *C*, *4*, *D*, *5*, *E* and *F* to the + brush on *7* and through the external circuit back to the — brush on *1*. The current due to the short-circuit flows from *2* to *B*, back to *3* and across the defect, consequently

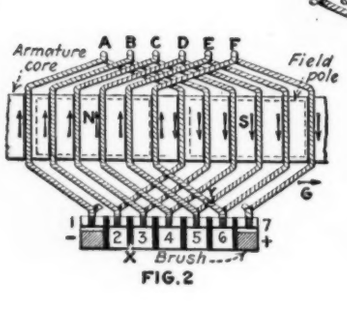


FIG. 2

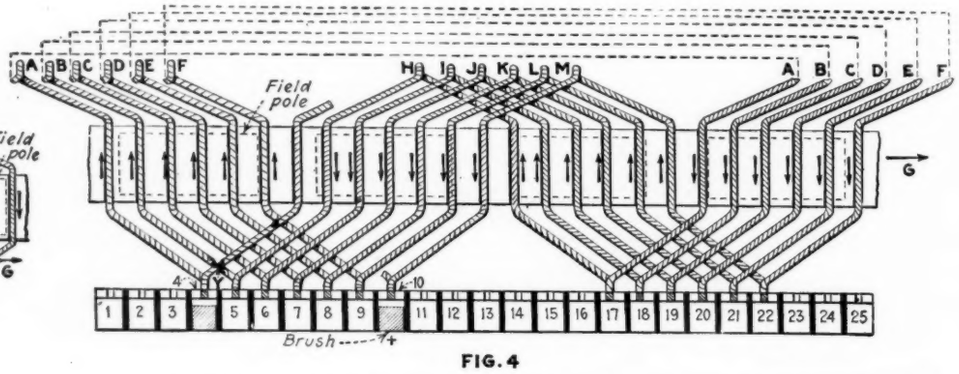


FIG. 4

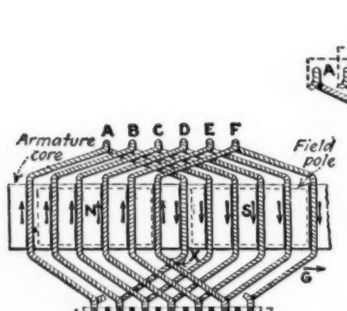


FIG. 3

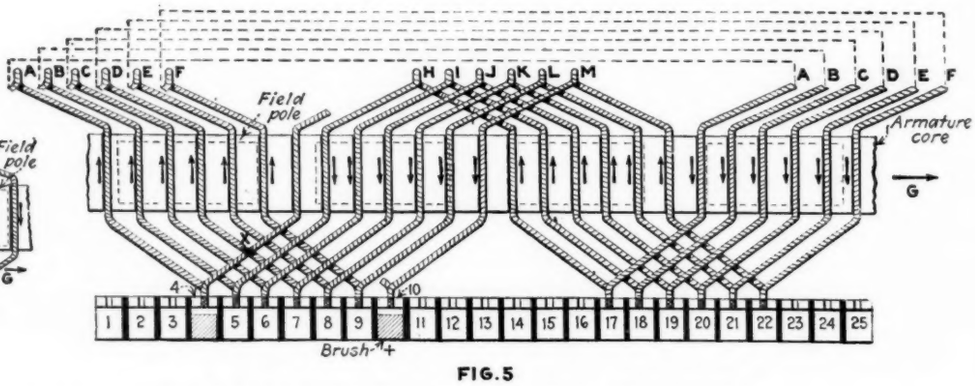


FIG. 5

FIGS. 2 TO 5. SECTION OF PARALLEL WINDINGS AND SERIES WINDINGS

*All rights reserved.

in the same direction as the main current. This short-circuit current exists whether or not there is a load on the machine.

With a short-circuit between the commutator bars the resistance of the contact is generally so high compared with that of the coil, that a large percentage of the energy transmitted through the closed-circuit is expended in the defect. Consequently, in a large number of cases, before the coil is seriously injured conditions on the commutator will become so bad as to

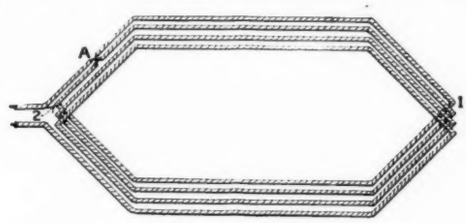


FIG. 6. COIL WOUND WITH SINGLE WIRE

draw the attention of an attendant and the machine is shut down. If the coil has not been destroyed, the defect can usually be remedied by cleaning out the charred mica and filling the hole with mica and shellac or commutator filler compound, of which a number of varieties are on the market.

If the insulation between two of the coil leads should fail at *Y*, Fig. 2, then a short-circuit of coil *E* would be formed from *5* to *E*, *E* to *6*, back to *Y*, then to *5*, thus completing the loop. In this case only coil *E* would be seriously heated, and if a good contact was made between the two leads at *Y*, it would probably be impossible to get the machine up to speed before the coil would begin to smoke. On the other hand, if the generator was brought up to speed without building up the voltage, when the voltage was brought up to full value the coil would be burned out before the machine could be shut down to prevent damage.

Insulation Failure Between Coil Leads

An insulation failure can occur between the leads so as to cause a number of coils to be short-circuited as a group. For example: if the insulation fails between the coil leads at *X*, Fig. 3, this would complete a short-circuit from *2* to *B*, *3*, *C*, *4*, *D*, *5*, *E* and *6* to *X*, back to *2*. This is sometimes referred to as a short-circuit on the half or on the quarter. When a group of coils is short-circuited as in Fig. 3, it will not only cause heating of the group, but also act as a heavy overload on the machine. If this were to occur on a motor while running, it would cause the machine to be so heavily overloaded as to blow the fuse or open the circuit breaker.

If an attempt were made to start a motor with a group of coils short-circuited, it would act as though starting under a heavy overload and would draw such a large current from the line as to cause the starting resistance to reach an excessive temperature in a very short period. The effect of this fault on a generator would depend upon the conditions under which it occurred. If the machine built up the voltage as it came up to speed, it would act as if it were heavily overloaded before it reached full speed. On the other hand, if the voltage did not build up until after the machine reached full speed, then when it did, the excessive current flowing in the armature coils would cause a heavy overload on the prime mover and slow it down; also, before the machine could be shut down the temperature of the coils would probably become so high as to destroy their insulation.

With a series-connected armature winding, the leads of the coils embrace approximately one-half of the commutator bars on a four-pole, one-third of the commutator bars on a six-pole and one-quarter on an eight-pole machine. In Fig. 4 is shown part of a single-series bar winding arranged for a four-pole machine. It will be noticed that the coil leads connect to commutator segments 13 bars apart. In tracing the circuit through the coils, two coils are passed through before leads come on adjacent segments. For example: starting from *4*, the circuit is to *A*, *17*, *H*, and to *5*. Now, if the insulation should fail between two segments, two coils would be involved instead of one as for the single-parallel winding.

If the machine, Fig. 4, had six poles, then three coils would be connected in the series between adjacent segments and for eight poles four coils between adjacent segments. Consequently, a short-circuit between two commutator bars on a single-series connected winding will cause heating of two coils on a four-pole machine, three coils on a six-pole machine and four coils on an eight-pole machine, instead of one on a single-parallel winding. Likewise, if the insulation were to fail between two leads as at *Y*, Fig. 4, then two coils would be involved in the fault and the circuit would be from *4* to *A*, *17*, *H*, *5*, *Y* and back to *4*. In this case the most serious heating would be in the coils and not on the commutator.

With contact between two coil leads as at *X*, Fig. 5, then the group from *4* to *A*, *17*, *H*, *5*, *B*, *18*, *I*, *6*, *C*, *19*, *J*, *7*, *X* and back to *4* forms a closed circuit, involving

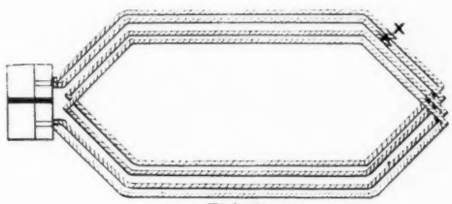


FIG. 7

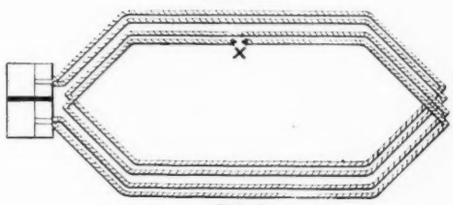


FIG. 8

FIGS. 7 AND 8. COILS WOUND WITH TWO WIRES IN PARALLEL

in all six coils. It is evident from this that the number of coils that may be affected by a short-circuit between coil leads will depend on where the defect occurs. The effect of the short-circuit, Fig. 5, will be the same as that described for Fig. 3.

Coils in small and medium-sized machines are usually wound with a number of turns of comparatively small wire, as shown in Fig. 6. With coils of this kind failure of the insulation between turns are not uncommon. For example: if two turns in the coil come in contact as at *A*, then there is a closed circuit from *A* to *1*, to *2* and from *2* back to *A*. Under this con-

dition with the coil in a machine in operation, a heavy current would circulate in the circuit and cause the coil to overheat. This condition would involve only the faulty coil unless it became so hot as to destroy its own insulation and that of the other coil in the same slot. In some small, low-voltage machines the coils are wound with two or more comparatively small wires in parallel, as shown in Fig. 7, and the leads connected to the

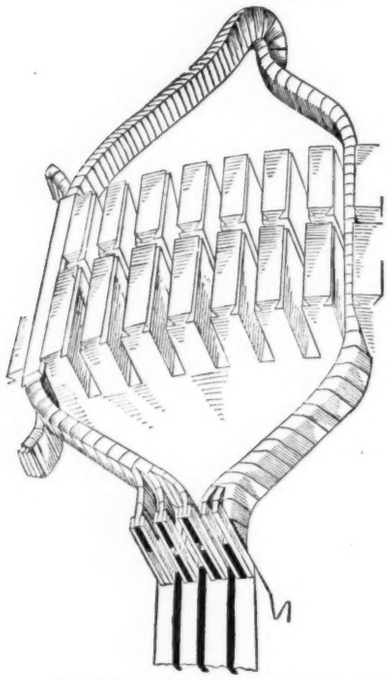


FIG. 9. THREE COILS GROUPED INTO ONE

same commutator bars as in the figure. If a connection between the turns of the independent windings in the coil occurred—for example: if the insulation was defective at *X* and the two conductors came in contact—no bad effects would result, since the two conductors are in parallel and may be considered as a single wire. However, if the turns of one winding in the coil were short-circuited, then this winding would heat just as the coil in Fig. 6 would under short-circuit conditions. In Fig. 7, if one winding in the coil became hot enough to damage its insulation, it would also damage that of the other. A short-circuit between the commutator segments, Fig. 7, would heat all windings in the same coil.

Where the coils in an armature winding are wound with a single conductor, an open-circuit in one coil creates an open in the winding, which is manifested at the commutator by sparking at the brushes and a burned spot between the segments to which the coil leads connect. With a coil wound with parallel conductors, as in Fig. 7, one winding could be open-circuited, as in Fig. 8 at *X*, and the other would complete the circuit. This might result in heating the coil to a temperature where the insulation would be destroyed, since it would be carrying double current. Sparking might also exist at the brushes, but not to the same extent as where the coil is wound with a single conductor. If the machine was operating under light-load conditions, it might continue indefinitely with one winding open in a coil, as in Fig. 8, without giving any signs of distress.

In some cases two or three coils are wound in one, as in Fig. 9, the three coils taped into one group and placed in the same slot as shown. A short-circuit between any two of the coils will have the same effect as a connection between the lead of two different coils as at *Y*, Fig. 2; that is, it will cause a short-circuit of one or more of the coils in the group.

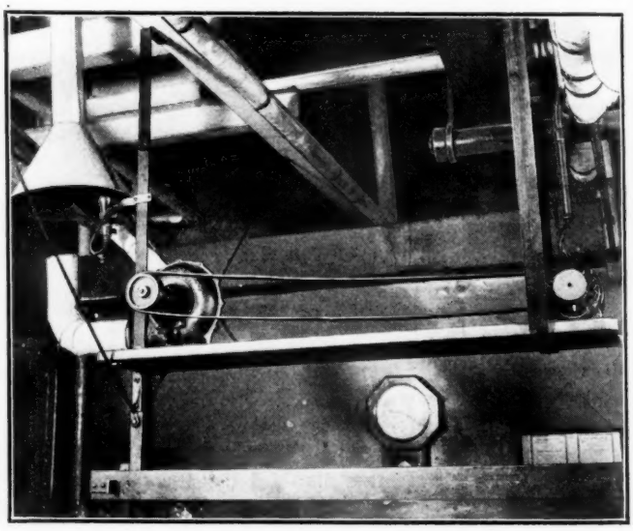
From the foregoing it is evident that troubles in an armature can develop under a variety of conditions. The method of locating the faults herein outlined, along with many other troubles in armature winding, will form the subjects for a series of articles of which this is the first.

Home-Made Smoke Detector

By Asa P. Hyde

The illustration shows a device that I made for our use several years ago when we were burning bituminous coal. Our stack is on the back side of the building in a light shaft, and we cannot see the top of it without going to the roof or out on the street, so that we cannot see when we are making smoke. I made this rig in order to see in the boiler room the amount of smoke that we are making and to enable the fireman to so handle the fire that he would not make smoke.

The fan is a small 10-in. exhauster driven by the motor, which is arranged to be easily started from the plant. The suction of the fan is a 2-in. pipe running into the boiler front just over the steam gage and back into the breeching where it will get a fair sample of the smoke being made. The sampling tube is about



ARRANGEMENT FOR DETECTING SMOKE

36 in. long and has several ⅜-in. holes drilled in the lower side to meet the smoke when rising up the flue. It then passes through the fan and out and into the funnel and the 4-in. pipe, which is connected to the stack side of the main damper, so that it always has a draft on it. The smoke passing to the funnel also passes a lamp which is automatically lighted, being in series with the fan motor, and the smoke is then easily seen.

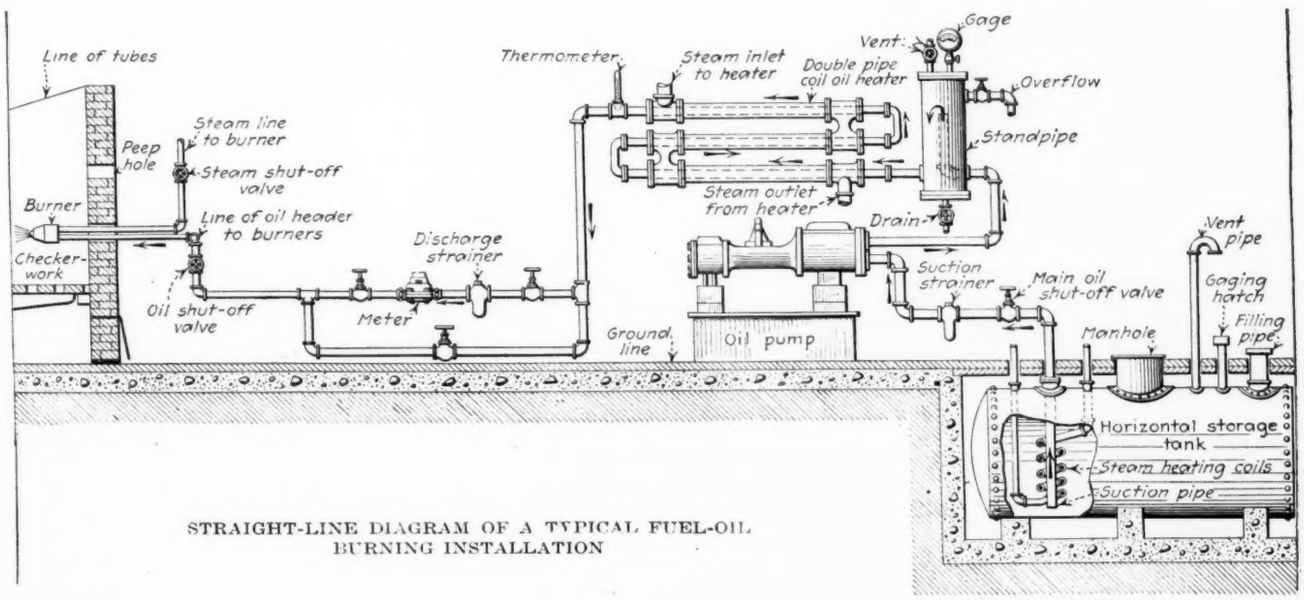
We know that it saved us coal, as we were always getting a sample of the combustion as made and so fired as to make the least amount of smoke. The rig is very simple and costs next to nothing to make.

The Installation of Oil as Fuel

By ALLEN F. BREWER

TO THE stationary steam engineer who is facing the problem of installing a fuel-oil burning system under boilers, either in a new plant or as a substitute for coal or other fuel, the selection of suitable equipment, etc., is an important item. The extent to which it may be necessary to go into the more exact details of types and sizes of tanks, fuel pumps, heaters, burners, piping, etc., will depend entirely upon whether he is proposing to make the installation according to his own ideas or is relying upon an oil-burning specialty firm to take care of the estimates, plans and specifications for his system. In the latter event it is assumed that the engineers engaged for consultation and the installation are reputable in this particular field.

It is primarily for the benefit of the former—the engineer who must prepare his own data to cover the requirements of his plant—that this article is presented. On the other hand, a knowledge of the details of a fuel-oil installation will, as well, be of advantage to the engineer who is permitted to assign his problem to consulting and installation engineers, because thereby he can check up their proposals and frequently make material changes therein for the betterment of future operation, owing to his greater familiarity with the manner of load to which his boilers may be subject.



STRAIGHT-LINE DIAGRAM OF A TYPICAL FUEL-OIL BURNING INSTALLATION

General Specifications Outlined

The general arrangement of a typical fuel-oil burning installation can best be discussed step by step, referring to the equipment the oil must pass through in its course from the storage tank to the boiler.

The size and type of tanks will depend on current, daily consumption, the grade of oil used and the distance from the source of supply. If the plant is at an excessive distance from the supply source, a reserve tank must be had to hold storage equal, perhaps, to several weeks' requirements. The size of such a tank only local conditions and the rate of daily fuel consumption can decide. In general, the tank is best installed vertically, located a safe distance (say one hundred yards) from the boiler house, to lessen fire hazard as much as possible in case of lightning striking it, etc.

Selection of Smaller Tankage

Granting that the problem of the reserve storage tank has been settled, the selection of adequate smaller tankage is next of concern. In this connection a number of points must be considered, such as rate of daily consumption, method of fuel delivery to the plant, distance from the base of supply, space available for storage, certainty of delivery at regular intervals, and Federal, state or municipal regulations as to hazard and insurance.

To meet the foregoing, there are three types of tanks from which to choose: Vertical, cylindrical steel; horizontal, cylindrical steel; and concrete, shaped as desired.

For the storage of smaller quantities of fuel, up to four hundred barrels, the horizontal tank is best adapted, when oil delivery is certain in a short space of time and the plant is generally accessible to a reserve fuel-oil supply, such as near a large tidewater city. Horizontal steel tanks are gastight, can be shipped assembled ready for setting up, and are easily handled by a normal plant force of men, with no riveting required on the job. They can be placed either above or below ground.

Vertical steel tanks are generally constructed for larger storage, from 400 to 64,000 bbl. capacity. They are shipped knocked down, requiring an erection and riveting gang to install. Such tanks are generally located above ground on a concrete foundation.

Concrete tanks are coming more and more into use for the average plant service. They can be built either above or below ground, are less costly than steel tanks, require less skilled labor to erect, are more permanent,

have a lower fire hazard, there is no possibility of corrosion, and they can be built in any desired shape, though rectangular, cylindrical and elliptical are the most common designs.

Whatever the type of tank to be used, it is advisable to refer to and follow the rules for the safe storage of fuel oil, as formulated by the National Board of Fire Underwriters. As a general rule the top of the storage tank should be set below the level of the lowest distribution pipe of the system (when underground tankage is used), to prevent flooding should valves leak, break or be accidentally left open when they should be closed. Underground tanks should be three feet below the ground surface, at least; all tanks should be outside of the boiler house and at least five feet from the building line, the exact distance depending on the size of the tank, according to the rules.

Table I gives sizes and capacities for the three types of tankage mentioned, and will be of value in guiding the engineer in deciding on the type to use according to his estimated required storage capacity.

Selection and Installation of Pumps

In practically every installation it is mandatory, according to insurance regulations, that oil be pumped from the storage tanks to the burners, inasmuch as a gravity supply is not permitted. With the heavier grades of oil that are fast becoming the only available liquid fuel, an oil pump is a necessity to insure a constant, even flow of the oil.

The selection of adequate-sized fuel-oil pumps is, therefore, the next important feature in the installation. The primary point to remember is that the pump capacity must be ample to serve the maximum boiler load that is to be carried. If possible boiler additions are to be made in the future, it is also well to take this point into consideration when the size of pumps is decided upon. It is acceptable practice, and recommended for the average installation, to use horizontal, duplex, cross-connected, piston-type, steam-driven oil pumps, installed in duplicate, designed for a working pressure up to 200 lb. The latter point (of duplication) is to permit of keeping one pump in reserve in order that no shutdown will be necessary should the pump operating fail for any cause or require to be cut out for repair or cleaning. As well, if need be, both pumps can be operated at the same time; one pump, however, should be capable of carrying the entire normal load. The advantage of the aforementioned type of pump over certain other types, such as centrifugal, triplex or rotary, for pumping fuel oil, are: Ability to handle varying volumes of oil with steady flow and little pulsation; little leakage of oil, thus reducing the fire hazard; ease of handling and making repairs, durability and comparatively low cost.

TABLE I. OIL-STORAGE TANK, CAPACITIES FOR MOST USUAL SIZES

Vertical Steel Tanks

Approx. Dimensions Diameter, Ft.	Height, Ft.	Capacity, Bbl. of 42 Gal.
52	35	13,600
52	30	11,700
42	30	7,800
42	25	6,500
38	25	5,000
30	35	4,400
28	35	4,000
30	30	3,770
28	30	3,450
30	25	3,140
25	30	2,620
23	30	2,400
23	25	2,000
23	20	1,750
20	25	1,400
20	20	1,100
19	15	800
15	20	630
15	15	470

Horizontal Steel Tanks

Approx. Dimensions — Diameter, Ft.	Length, Ft.	Length, In.	Capacity, Bbl. of 42 Gal
6	21	5	107
6	29	11	151
7	25	8	175
7	29	11	203
8	25	8	230
8	29	11	267
9	25	8	291
10	25	8	359
10	29	11	418

Reinforced Concrete Tanks

Dimensions, Ft.	Shape	Capacity Bbl. of 42 Gal.
16x10	Round	360
45x16	Round	4,330
63x11	Round	5,240
125x12	Round	23,800
72x72x10	Square	10,710
20x10x10	Rectangular	380
29x14x10	Rectangular	710
68x21x21	Rectangular	5,120

Fuel-oil pumps should always be so located as to be accessible. Particular care should be paid to the suction pipe lines. Locate them as close to the storage tank as possible, to reduce friction in the suction pipe; locate close to floor to reduce suction lift; maintain suction pipe as free from bends, ells, valves and other fittings as possible, to reduce friction; slope gently upward as it approaches the pump; if in a cold climate, install underground or in a wooden trough suitably drained and packed with sawdust, etc., to prevent chilling of the oil as much as possible.

TABLE II. SIZES OF FUEL-OIL PUMPS WITH APPROXIMATE CAPACITIES

Size, In.	Approximate Boiler-Heating Surface per Pump*	Normal Max. Pump Capacity Gal. per Min.	R.P.M.†
3 x 2 x 3	4,000	5–8	55
3½ x 2½ x 4	6,000	8–12	50
4½ x 2½ x 4	10,000	12–20	50
5¼ x 3½ x 5	25,000	20–35	45
6 x 4 x 6	40,000	35–50	40
7½ x 5 x 6	75,000	50–80	40
9 x 5¼ x 10	100,000	80–125	35

* For an oil of below 18 deg. Baumé gravity. † Rated normal maximum. With an average evaporation of 14 lb. water per pound of fuel oil, there will be required about ⅓ gal. of oil per minute per 1,000 sq.ft. boiler-heating surface. When an extra-heavy oil is to be used—that is, below 12 deg. Baumé gravity—it is well to select the next larger size of pump than the one commonly required.

Oil pumps should be fitted with a suitable pump governor to regulate the steam supply according to pump capacity demanded. The principle of such a governor is that oil pressure acts on the top of a diaphragm and tends to close the steam valve at an excess of oil pressure or, vice versa, to open it should this pressure drop for any cause, such as increase in load, etc. Table II gives sizes of fuel-oil pumps with approximate capacities.

For more particular details concerning the care and operation of fuel-oil pumps, see "The Efficient Handling of Fuel Oil," *Power*, page 223, Feb. 8, 1921.

Standpipes Versus Air Chambers

In order to insure a non-pulsating flow of oil, however the pump may be operating, a standpipe or air chamber installed in the oil line between the pump and heater is an excellent investment and advisable, although not absolutely essential. The basic idea is shown in Fig. 2 of the article, "The Efficient Handling of Fuel Oil."

In brief, a simple piece of 12- or 18-in. pipe about 6 to 8 ft. long, set vertically and fitted as shown in the sketch, will be adequate for the passage of fuel sufficient for a plant having an average of 50,000 sq.ft. of boiler-heating surface per pump.

Heaters Are Required for Fuel Oil

In order to insure proper atomization and combustion of fuel oil as it passes from the burner into the furnace, it is practically a necessity to heat it to a sufficient degree to reduce its viscosity and sluggish condition, in order to enable it to flow freely, with the desired rapidity and no pulsation. In other words, the oil stream to the burners must be constant and continuous as long as the boilers are firing. To attain this purpose, an oil heater must be installed. Heating is most commonly carried out, using live or exhaust

steam. If the desired oil temperature is to be below 200 deg. F., exhaust steam will be found adequate, but above this temperature live steam will be most suitable.

Fuel-oil heaters may or may not be constructed as integral parts of the oil pumps. It is becoming more and more popular, in the case of coil heaters, to adopt this latter feature, and many manufacturers of such specialties are building their particular type of heater attached to the pump. This is, by no means, however, an essential feature, and certain types of very efficient heaters such as the double pipe (ammonia fitting) coil and the corrugated film-type heater are installed independent from the pumps.

Types of Heaters Available

The most common types of heaters available, from a service and economy viewpoint, for average plant service, are the endless coil within a receiver; the double-pipe coil, and the straight-pipe, return-tubular coil within a receiver. There are numerous other types, the products of certain specialty manufacturers, which show as great or greater heat-transfer efficiency than the foregoing; but, owing to their intricacy, general high cost and the necessity for special construction, they are omitted from this discussion, as the aim is to treat of general principles rather than specific ideas.

The endless-coil heater, so called because of the helical shape of the heating coil, consists of a common receiver containing one or more coils of seamless drawn, copper, brass or iron pipe tubing. For high-sulphur oils the iron pipe is preferable owing to its durability. Heating is carried out by passing live or exhaust steam through the coil, the oil surrounding the latter and generally entering and leaving at opposite sides of one head of the receiver, which is so constructed with outside joints as to be easily removable for cleaning sediment and dirt from the receiver.

The double-pipe coil is one of the most practical and efficient types within reach of the average plant today. It can be constructed at low cost, by plant labor, using standard ammonia end fittings and straight lengths of 2-in. within 3-in. wrought-iron pipe. Oil passes upward in one direction through the 2-in. pipe, and steam passes downward through the 3-in. pipe in the opposite direction, surrounding the oil pipe. Such a heater provides a counterflow of the liquids, the rate of heat transfer is high for the amount of heating surface, and all joints are external, facilitating cleaning, inspection and repair.

TABLE III. HEATING SURFACE VS. CAPACITY OF FUEL-OIL HEATERS

Approx. Sq.Ft. of Heating Surface Required*	Approx. Sq.Ft. Boiler-Heating Surface	Approx. Normal Maximum Gal. per Min. Passing Through Heater
15–20	4,000	5–8
20–25	6,000	8–12
25–40	10,000	12–20
40–50	25,000	20–35
50–100	40,000	35–50
100–150	75,000	50–80
150–200	100,000	80–125

* Depending on grade and gravity of oil; heavier oils will require somewhat more heating surface.

The straight-pipe, return-tubular coil within a receiver is perhaps the most cheaply and easily constructed of any heater, by average labor. Standard pipe and fittings can be used throughout, and it can be built on the job in half a day or less. The rate of heat transfer is not so great as in the other types of heaters mentioned, hence to attain the same degree of heating approximately 25 per cent more heating surface should be figured on. For an average plant of, say, 4,000- to 6,000-sq.ft. boilers, a heater composed of a receiver of 18-in. pipe, flanged, about 10 ft. long with four to six lengths of standard 1-in. pipe connected up with standard return bends to form the heating coil will be found to give the desired results in heating a Mexican crude oil to 200 deg. F. Either live or exhaust steam can be used. The oil fills the body of the receiver surrounding the heating pipes, entering at one end and leaving from the other. All heater joints are external, facilitating easy and rapid removal for cleaning, inspection and repair.

For further data relative to the method of operation and care of heaters, as well as a table of heating temperatures for various grades of oil, and sketches of the double pipe-coil and straight pipe-coil heaters, see the article already mentioned.

Table III, which gives heater capacities in square feet of heating surface for various boiler-heating surfaces, can be used to advantage in deciding on the size of heater to use for the installation based on the size of the latter and the approximate volume of oil flow desired.

Fuel-Oil Strainers Are Necessary

Owing to the fact that all fuel oil will contain a certain amount of base sediment and dirt, strainers are an essential part of every installation. In good practice it is customary to install a pair of such on the suction side of the pump, to remove larger particles of foreign matter and serve as protection for the pump chambers, particularly if a crude oil is to be fired. Duplicate strainers are installed on the discharge side as well, after the oil has passed through the heater, to remove all final particles of dirt, shreds of packing or scales, etc., and prevent such from passing to the burners to score or clog them. Suction strainers may or may not be a requirement, depending upon the engineer's opinion of the quality of his oil and the guarantee he receives at its delivery, or a desire to reduce first expense of the installation. Discharge strainers, however, should always be installed.

The sizes of strainer mesh will be important in this connection. It is generally agreed that the mesh on suction strainers need not be less than sixteen per inch. On the discharge side, however, the strainer mesh should not be less than forty per inch.

It will be found advisable to install a vacuum gage on the tank side of suction strainers as well as on the heater side of discharge strainers. Such gages will indicate, by a drop in vacuum, when the strainers are in need of being cleaned.

Oil-fuel strainers are in general marketed according to the size of the piping on which they are intended to be installed. The simplest, home-made types of strainers are the blind wire-gauze gasket, held between two flanges, and the tee-fitting strainer. For more detailed discussion of strainers and sketches of the latter type, as well as the simple basket type, both of which are very practical, cheap and serviceable, see the article previously mentioned.

Piping for Fuel-Oil System

The question of size of piping to use is most important in the installation of a fuel-oil burning system. In this connection there is one essential point to be taken into consideration; that is, friction head, or the pressure in pounds per square inch required to over-

come the friction occurring between the pipe and oil when the latter flows through the former.

It is well known that friction head increases with the gravity (and viscosity) of the oil, the velocity of the oil in its flow, the length of piping, and the number of sharp turns met with during the flow. Only the last two of these factors can generally be controlled in making the installation, and it is well to decrease them as much as possible, keeping the line as straight as practicable and using as few fittings as can be, as well as installing gate valves instead of globe valves wherever valves are required.

To arrive at the proper diameter of piping to be used in the system, it is well to consider the oil at its maximum, normal velocity; that is, in its course to the burners after leaving the heater. The first calculation is to decide upon the quantity of oil to be fed under maximum conditions. As has been previously stated, with an evaporation of 14 lb. of water per pound of oil, about one-half gallon of the latter will be required per minute per 1,000 sq.ft. of boiler-heating surface. Therefore, we can arrive at a probable oil consumption per hour, knowing the maximum boiler demand that will probably be required. For the purpose of an example call this 25 bbl. per hour.

The next item of consideration is the maximum normal velocity that may be required. Inasmuch as this will depend on the viscosity of the oil and the latter point will in turn depend on the degree to which the oil is heated, it is deemed fair herein, for the purposes of an example, to assume a fair normal viscosity figure. In marine practice it is recommended to heat fuel oil until it is reduced to a viscosity of 8 to 10 deg. Engler. For stationary practice this figure can be well estimated at 20 deg. Engler, due to the more favorable conditions. Therefore, using the formula,

$$Velocity\ (feet\ per\ minute) = \sqrt{\frac{200{,}000}{Viscosity\ deg.\ Engler}}$$

where 200,000 is a constant, we have,

$$Velocity = \sqrt{\frac{200{,}000}{20}} = 100\ ft.\ per\ min.$$

With the probable maximum velocity decided upon, the diameter of the oil piping necessary can be calculated as follows:

$$Diam.\ of\ pipe = 4.1\sqrt{\frac{Required\ flow\ in\ bbl.\ per\ hour}{Velocity\ in\ ft.\ per\ min.}}$$

Assuming a maximum flow of oil required at 25 bbl. per hour,

$$Diam.\ of\ pipe = 4.1\sqrt{\frac{25}{100}} = 4.1 \times 0.5 = 2.05\ in.$$

Therefore, a 2-in. pipe will be necessary for the maximum oil consumption of the boilers at peak load.

In best practice oil-distribution piping should be installed without dead ends, preferably in accordance with return-circulating principles; thus oil will be flowing at all times, deposits in the line will be decreased, and the oil will retain its heat better, and as well, the heat contained by the surplus oil can be used in heating the oil drawn from the storage tank. In operation, oil-distribution lines should be blown out with high-pressure steam at regular intervals to insure clean pipes and prevent deposits.

The size of the oil-distribution lines from the oil header to the burners can safely be taken, in practically all cases, at ¾- to ½-in. To an extent this will depend on the number of burners in use; and, as a general rule, the total area of oil-burner piping should approximately equal the area of the oil header.

Steam-header piping to burners can safely be taken at about two sizes less than the oil header, the lines to each burner being the same size as the oil-burner piping.

Oil Meters Are Essential

In order to burn fuel oil in an efficient manner, with accurate knowledge of the rate of evaporation being attained, an oil meter is a practical necessity and a well-paying investment. It may be possible in many cases to gage the storage tanks, but as a check on this process a meter should be installed and is advisable. It will, as well, impress the fireman that his rate of firing is being watched and will urge him to fuel economy, inasmuch as he can watch his rate of oil flow as frequently as he may desire, according to the load he is carrying on the boilers. Either a piston- or rotary-type meter may be used for this purpose. Such instruments, properly cleaned and cared for, will register within 1 per cent. Meters should be installed between the oil heater and the burners, the meter should be as large as the pipe in which it is to be placed, and it should always be located on a bypass to permit of cutting out of service for cleaning or repair, etc. An oil meter will frequently pay for itself in a few days in a case where fuel is being wasted, if the chief engineer watches the flow at periodic intervals. Thereby he can learn which of his fireman is guilty of the waste and correct this procedure promptly and effectively.

TABLE IV. FUEL-OIL METER SIZES, WITH APPROXIMATE CAPACITIES AND BOILER-HORSE-POWER SERVED

Size, In.	*Approx. Normal Maximum Flow in Gal. per Hr	†Approx. Maximum Boiler Heating Surface Capable of Being Served
¾	300	10,000
1	600	20,000
1	900	30,000
1½	1,500	50,000
2	2,400	80,000
3	4,200	120,000

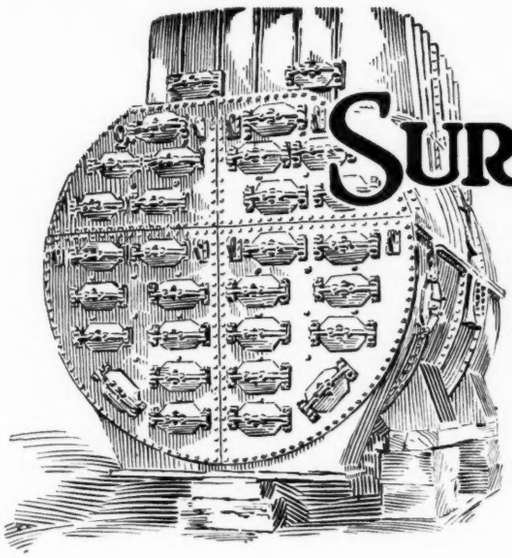
* To a certain extent this will depend on the grade of oil, its viscosity and the degree to which it is heated before metering.

† Based on an average fuel consumption of one-half gallon per minute per 1,000 sq.ft. boiler-heating surface, at an average evaporation of 14 lb. of water per pound of oil fired.

The accompanying diagram shows the basic elements of a typical fuel-oil burning installation. To maintain simplicity, it has been deemed best to omit steam lines, minor optional equipment, such as governor, etc., and the return oil line. The layout, to be most distinct, has been shown in straight-line form, though to suit the boiler room it might be installed differently. Table V shows the approximate sizes of equipment used and is taken for the most usual size of smaller plant; that is, 4,000-sq.ft. boiler plant.

TABLE V. EQUIPMENT LIST FOR A 4,000-SQ.FT. BOILER FUEL-OIL BURNING INSTALLATION

Material	Size
Storage tank	10-foot diameter, by 29 ft., 11 in. long. Assuming oil delivery can be obtained daily if required. Horizontal, steel tank.
Main oil piping	Standard malleable iron, 1½-in. standard fittings.
Oil pumps	3 x 2 x 3-in. duplex, horizontal, steam-driven, installed in duplicate.
Oil heater	Three 20-ft. lengths of standard malleable iron 2- and 3-in. pipe to form a double-pipe coil, standard ammonia fittings used on ends; 18 sq.ft. of heating surface. Oil capacity 5 to 8 gal. per min.
Meter	Standard ¾-in. type.
Number of burners	Depends on number of boilers installed. Usually one burner per boiler; or, if more than one burner, use one burner per 2,000 sq.ft. heating surface.



Surface Condenser Operation

By George C. Cook

IN THE OPERATION of surface condensers the main object to be attained is the best economy possible under the actual operating conditions, for the complete unit—that is, turbine and auxiliaries—although this condition may not in all cases be that giving the highest attainable vacuum.

The vacuum obtained is affected by a great many variables. Considering the design fixed, the vacuum is dependent on the load, the circulating-water inlet temperature, the quantity of circulating water through the condenser and the coefficient of heat transmission.

These quantities are to some extent interdependent, and a change in one is usually accompanied by a change in some of the others. An increase in load is in general followed by a decrease in vacuum. This decrease, however, is not directly proportional to the load, and the vacuum will fall off at an increasing rate as the load increases.

Vacuum Decrease With Temperature Increase

With increasing temperatures for the inlet circulating water and constant load and quantity of circulating water, the vacuum carried will decrease and at a greater rate than that proportional to the increase in temperature. This is explained as follows: Consider for the moment that the heat absorbed in the condenser is constant and equal to the product of the square feet of cooling surface, the coefficient of heat transmission and the mean-temperature difference between the steam and water. The cooling surface is assumed constant. The coefficient of heat transmission is known to increase only very slightly with increased temperatures, and the temperature rise in the circulating water is found in practice to be practically uninfluenced by the inlet circulating-water temperature; therefore the mean-temperature difference will be practically constant and the temperature of steam in the condenser will increase as the inlet circulating-water temperature rises. However, it will be seen by a glance at the steam tables that the pressure of saturated steam rises at a constantly increasing rate as the temperature is increased, so that the vacuum in the condenser will fall off more and more rapidly as the temperature in the steam space rises. For the purpose of the foregoing explanation it was assumed that the quantity of heat to be transmitted was constant, but in fact this also increases as the inlet circulating-water temperature increases owing to the poorer vacuum and resulting higher steam consumption of the turbine, which still further augments the rate of decrease of vacuum with increase in inlet circulating-water temperature.

Quantity of Circulating Water Required

The quantity of circulating water to use is an operating problem; in general it may be said that on a given condenser for any one load and inlet circulating-water temperature there is a point above which an increase in quantity of circulating water will not result in any appreciable increase in vacuum; decreasing the quantity below this point results in a drop in vacuum, the rate of decrease of vacuum increasing faster than the rate of decrease of circulating water.

In the consideration of this problem the pump equipment is frequently the determining factor. Where the circulating pump is driven by a constant-speed induction motor, it is usually found that there is little gain in power consumption by throttling the inlet or discharge circulating-water valves, consequently in this case, where the supply is adequate, it will be found advisable to use the full quantity at all times. In cases where the circulating pump is driven by a variable-speed motor or turbine, that speed should be used which will give the lowest heat consumption for the main turbine and auxiliaries as a unit and which may not always be the condition giving the highest vacuum. The use of a steam-flow meter measuring the total steam to turbine and auxiliaries is a great help in determining the best speed for the circulating pump. Temporary shortages in the condensing-water supply may necessitate using less than the desired quantity. Where the circulating-water system is arranged to produce a siphon action of the water passing through the condenser, advantage should be taken of this so as to reduce the work of the circulating pump; and to this end all joints, valves, steam packings, etc., must be kept tight so that this siphon action will not be destroyed.

Air and Steam Distribution Considerations

The items affecting the coefficient of heat transmission other than those involved in the design of the condenser, are the amount of air entering the condenser and the completeness of its removal, the effec-

tiveness of the steam distribution throughout the condenser and the physical condition of the cooling surfaces.

Air enters the condensing system in two distinct ways: First, entrained in the steam, and second, by leakage into the system at points where the pressure is less than atmospheric. Air entrained in the steam may originate by mechanical entrainment in the feed water, by solution in the feed water and by placing fresh boilers on the line without first bleeding off the air. Air in solution may be reduced by heating the feed water to 212 deg. F. in an open heater, since the solubility of air in water decreases with a rising temperature until at 212 deg. it is practically insoluble. A large amount of the air mechanically entrained will also be liberated in the open heater.

By far the greater part of the air entering the condenser comes from leakage into those parts of the system under a vacuum, and since this leakage is largely under control of the operator, no effort should be spared to keep it at a minimum. Attention should be given to seeing that the carbon packing at the low-pressure end of the main turbine is in good condition and effectively sealed at all times, also that the atmospheric relief valve is well sealed. Care must be taken to see that all joints, valve-stem packing, etc., on the exhaust piping or connections leading to the steam space of the condenser are maintained tight. It is advisable to paint the joints at intervals with asphaltum paint, also the condenser shell and exhaust connection to the turbine, to insure closing up all pinholes or porous spots. In this connection a warning should be given against the too common practice of making connections to the condenser for the purpose of priming pumps, laboratory use, etc. This practice is greatly to be deplored when high vacuums are desired since it gives many more joints and valves to leak and increases the difficulty of maintaining a tight system.

Air Entering the Condenser Must Be Continuously Removed

With all achievable precautions taken, it is still impossible to exclude all air from the condenser, and that entering must be continuously and effectively removed to obtain satisfactory results. With the rotative dry vacuum pump one of the most frequent causes of unsatisfactory operation is the clogging up of the valves and port passages in the air cylinder from carbonization of the lubricating oil. When this trouble is encountered, it will be found to be due to using an improper grade of oil and probably an excessive amount. The remedy is to change the kind of oil (a high-grade air-compressor oil is usually suitable) and cut down the amount that is used to the minimum compatible with proper lubrication.

Precautions should be taken when operating this type of pump to guard against flooding of the condenser due to stopping of the hotwell pumps or otherwise, as in this case water will be carried over into the dry vacuum pump with serious results. With this type of pump the air entering the condenser system may be easily measured by means of a gasometer attached to the pump discharge; this gives an excellent means of checking up the tightness of the system. Where the hydraulic vacuum pump is used, expected results are sometimes not obtained because of a lack of cool hurling water. With this pump the highest vacuum obtainable at the pump is that corresponding to the temperature of the hurling water; moreover, the volumetric efficiency of the pump increases with colder circulating water. The temperature of the hurling water should be kept as cold as or colder than the inlet circulating water.

The coefficient of heat transmission is affected very largely by the physical condition of the tube surfaces, the highest coefficient being attained when they are bright and clean. As the tube surfaces become oxidized or pitted, the coefficient decreases, also with the deposition of foreign matter such as scale, mud, sand, etc.

Removing Deposits From Inside Surfaces

The deposits on the inside surfaces of the tubes must be removed from time to time as the vacuum shows signs of impairment from this cause and as operating conditions permit. If the unit can be kept out of service but a brief interval, one of the following methods may be used: If the trouble is caused chiefly by débris such as leaves, straw or small fish, etc., clogging the openings of the tubes, it may often be removed very quickly by draining the water boxes through a 6-in. connection at the bottom; soft deposits of mud or silt may be washed out by means of a high-pressure stream of water directed through each tube by means of a nozzle.

A method requiring more time, but which is more effective, is that of shooting leather disks (with a nail through the center of each to guide its movement) through the tubes by compressed air. To save time, the disks may be shot through one pass by one gang of men and in a reverse direction through another pass by another gang.

Baking of condensers is sometimes resorted to and is done by opening doors in the water boxes to allow a full circulation of air and at the same time admitting steam to the steam space of the condenser. The steam admitted is regulated so as to bring the temperature to 180 deg. F., at which point it is maintained for two hours. By this procedure accumulations on the inside of the tubes are dried, curl up and peel off and are carried out by the circulating water when the unit goes into service. This method has the objection that it may cause the tube packing to loosen up and leak.

Other Methods of Cleaning

More thorough methods of cleaning, which are employed when the unit can be taken out of service for a sufficiently long period, are the wire-brush method, the tube-boring machine and the sandblast. In the wire-brush method a stiff round wire brush is pushed or pulled by means of a long rod through each individual tube. A good job is done by this method with little damage to the metal of the tubes. Where hard scale is encountered, tube-boring machines are sometimes used, but the cleaning is particularly slow and the wear and tear on the tubes is a factor. The use of the sandblast is probably the most satisfactory and expeditious way of removing the deposit. About a quart of clean, sharp sand that has been dried should be used to a tube. One operator can clean about 100 tubes an hour. The heat transmission after thoroughly sandblasting the tubes is usually as good as, and sometimes better than, when the unit was originally installed. If care is taken, there will be little cutting of the tube metal.

Sometimes, though rarely, an oily deposit will be found on the outside surface of the tubes. This may be removed by pumping kerosene into the first stage of the turbine (through the first-stage gage connection)

and pumping the condensate overboard. This procedure should be continued until the condensate is seen to be clear, when it will be found that the outside tube surfaces are clean. The use of kerosene in this manner will also tend to remove dirt and scale from the blading.

Temperatures and pressures in the steam space bear a most important relation to each other. The pressure in the steam space is the sum of the partial pressures of the steam and air. The pressure of the steam is the pressure of saturated steam at that temperature—that is, the temperature of the steam space—and may be found in the tables for saturated steam. The air pressure is the difference between the absolute pressure as measured and the pressure corresponding to the temperature. With efficient air pumps and a tight system the air pressure should be practically negligible. This feature should be continually watched so as to prevent loss of vacuum from the pressure of air in the condenser.

In all surface condensers there is usually more or less leakage of the circulating water into the steam space. While this is seldom sufficiently serious to affect the vacuum, it may cause a great deal of trouble by contamination of the condensate. The presence of this leakage may be detected by chemical, electrolytic and direct methods.

Where chemical methods are employed the exact procedure to be followed must be determined for each individual case and is largely dependent on the chemical composition of the circulating water.

The electrical conductivity of the condensate is affected by the amount of impurities contained, so that since these impurities are derived from the circulating water by leakage, it is possible to use the relative electrical conductivity of the condensate as a measure of this leakage.

The leakage may also be directly determined by means of either the candle or the water test. Both must be made when the unit is out of service; in the former, the heads of the water boxes are removed, the vacuum pump started, and the surfaces then explored with a candle to find the points at which leakage occurs; in the latter, after the heads of the water boxes are removed, the steam space of the condenser is filled with water and one is then enabled by visual observation to detect where the leaks are. Before applying the test in the case of condensers supported on springs and rigidly connected to the turbine casing, precautions should be taken that the weight of the water will not distort the casing or throw the turbine out of alignment.

Pointers for the Small Power Plant Operator

By William W. Edson

If one will inspect various power plants in the smaller cities, many will be found lacking in cleanliness, efficiency, reliability and reputation. A boiler and an engine will be tucked away in some basement and forgotten by the management until trouble starts.

The small power plant covers a field of utmost importance, and the large number of them, when considered together, amounts to an important item in the saving of fuel. Each pound of coal or each dollar saved in a small plant means a relatively large percentage of the total.

Most of the articles and books published apply to the large plants. Test results of such plants are always interesting and appear spectacular. The erecting engineer considers the size of the plant as an advertisement. The operators of small plants probably need help more than those in the larger plants.

The small plant changes hands or management so often that it suffers from changes in policy. One party may be too conservative and hang on to old equipment, regardless of efficiency or reliability, and trust that nothing will happen until their time is up. Another management may go to the other extreme and buy new equipment rather than repair the old. For these reasons a plant should select a list of definite instructions on operation and stick to it. Most firemen, engineers and superintendents get their first experience in the small plant, and it is there that they should form habits of cleanliness, reliability and efficiency.

The first important item in the reduction of power-plant expenses is efficient and reliable machinery, the proper arrangement and duplication of units and steady and efficient operators. There is not much opportunity to reduce the fixed expenses such as interest, depreciation, insurance, etc., but the more hours a machine operates and the larger the load it carries the less the fixed charges will affect the cost of output. The closer the load approaches full-load conditions and the steadier this load the more efficient the apparatus becomes. These principles of operation of the units also apply to the plant as a whole.

The number of men employed may be reduced by overlapping the shifts on peak loads. A similar method is to use three nine-hour shifts, thus giving an hour in which the new engineer can make his inspections, read the meters and help the relieved engineer on any work requiring two men.

A surprising amount of repairs and maintenance can be saved by drawing up a schedule on the operation and care of the machinery and then living up to it. For instance, the following report is a guide for duties in addition to the daily ones:

Time	Item	Remarks	Completed By
Each Sunday	Wash out heater.		
Monthly			
First week	Clean heater trays. Clean boiler tubes. Examine boiler setting and baffles. Make firing and draft test		Checked by Supt.
Second week	Clean all motors and generators. Measure air gaps. Drain, clean and fill all motor and pump bearings. Clean all oil strainers of turbines. Test overspeed kick out on turbines		Checked by Supt.
	Test and record full-load current of motors.		
Third week	Finish any of the foregoing duties not completed.		
Fourth week	Overhaul, pack, etc., any pump or machine not in 100 per cent running order.		
Each one-half year.			
First month	Test lightning arrester (also test after each storm). Inspect oil in motor starters. Inspect oil in oil switches. Clean entire boiler. Inspect fire extinguishers		Checked by Supt.
Second month	Change oil in No. 1 turbine.		
Third month	Change oil in No. 2 turbine.		
Fourth month	Change oil in No. 3 turbine.		

It usually will pay to buy a small non-condensing turbine or engine set to run at night and on Sundays. Usually, one man can act both as fireman and engineer in this case.

Close the valves on the lines or turbines not in use to avoid loss from radiation and condensation and to prevent a possible distortion of the turbine rotors. Open drains on units not under steam pressure. Note that each additional inch of vacuum means a saving of about 2 or 3 per cent of coal.

Reduce the electrical losses by selecting generators and transformers suitable for the load, by clearing all lines of grounds, by using the proper size of wire, by

keeping all consumers on meters and by raising the power factor.

Low power factor is mainly caused by induction motors and transformers being underloaded. It increases the loss in the generators, lines and transformers and causes a material reduction in their capacity. It also causes poorer voltage regulation. The power factor may be raised by buying apparatus of the proper size. If the motor has to start under heavy load, select a slip-ring motor rather than a squirrel-cage motor of oversize. For large motors having a steady load use a synchronous motor.

If a three-phase induction motor is belted to a machine, and the machine is to be reversed, interchange any two wires on the motor; it is not necessary to put on a crossed belt.

Install a switch, fuse and meter on each electric circuit in the plant, run the wires through conduit, put the plant lights on a night and on a day circuit. Have each feeder line equipped with a lightning arrester and choke coil.

Lead cooling air ducts to the generators from the outside. Arrange to discharge the air into the turbine room in winter and outside the plant in summer.

Have plenty of extension lights and electric fans. Connect factories on separate feeders from lighting customers.

Proper Size of Units Important

Be careful about having the generator capacity correspond to the boiler capacity. It is better to have three similar units, any two being capable of carrying full load, than to have two large ones, each being able to handle full load.

Install an alarm to operate when a circuit breaker opens, and install safety screen doors at the rear of the switchboard.

Install lightning arresters and choke coils in the primary of each distribution transformer. Ground the neutral wire on all secondary circuits if there is one, or the mid point of any one of the transformers in the bank if there is no neutral. A choke coil for moderate voltages can be made by forming a coil of about twelve turns six inches in diameter, and carefully taping each turn, first separately, then together, to hold the coil together. A spiral method suitable for higher voltages is to form a spiral coil by winding the transformer leads around a 2-in. stick.

Any time a generator is disconnected or overhauled or when any changes are made in the synchronizing circuits, test the phase relations as follows: Disconnect the wires at the generator terminals; have another machine running and tied in on the board; throw in the oil switch of the disconnected generator and insert both synchronizing plugs. The synchroscope should point exactly to 0; if not, its hand has slipped or there is something wrong with the circuits.

Note which way any three-phase motor is running when connected to the machine that is running. Clear the entire switchboard and shut down the unit. Connect up the generator to be tested and start it up. Then start the motor and observe its direction of rotation. If it is backward, reverse any two of the connections at the generator's terminals. The generator is now ready to be synchronized with the other generators.

It costs money for every pound of coal or each kilowatt-hour lost in the plant. Reduce water loss by installing meters and by a device to prevent overflow of storage tank and by stopping all leaks. (Use expansion joints where absolutely necessary.)

Discharge oil cooling water from a turbine to a heater. Also return all trap discharges to a heater.

Arrange for two sources of condenser cooling water if possible and arrange to save the cooling water when necessary.

Install a city pressure line to the heater for emergencies. Have large pipes for all drains and use plugged tees instead of ells. Arrange to draw feed water from the heater, city mains, cistern and anywhere else available. Arrange to fill boilers by city pressure.

If deep-well pumps gradually run dry, perhaps the well is filling with sand.

Install a siphon on top of a centrifugal pump to prime it, as well as having a method to prime it by filling the pump with water. Install siphons on all pits that might become filled with water.

Arrange to take steam for running feed pumps from steam headers or from individual outlets on the boilers.

Install an air chamber on the suction line of the feed pumps to prevent uneven, jerky strokes. Place the heater several feet above the suction line of the feed pumps. See that all centrifugal pumps are revolving in the proper direction.

Keep all steam pipes and boiler surfaces covered with insulation.

Have water line running to the boiler turbine cleaners separate from the rest of the system so that the pressure may be raised.

Have two feed lines running to each boiler. Have two blowoff valves on each boiler. Keep everything painted.

Do not use square nuts on pipe flanges which must be made tight. Piping to be connected to a turbine should be matched up in position before bolting to the machine. The piping at this point should be able to be moved in all directions by hand. It may be supported in place by springs. An expansion joint on the exhaust line having a vacuum may have limit stops to prevent collapsing, due to the upward atmospheric pressure.

Post in the boiler room instructions on the care and operation of boilers and settings. Likewise post a discussion on methods of firing.

Make out a list of causes of losses in the entire plant. As these losses are reduced check them off.

Have plenty of shelves for supplies, packing, etc. Hang up a card showing the exact size and length of packing ring for each machine in the plant.

Keep the building walls and roof in good shape and keep the windows repaired; have locks on all doors; use screens in summer.

Asphaltum paint is good for stopping leaks in vacuum lines.

Arrange for the damper to be closely adjusted from the front of the boiler near the draft gage.

Build a workshop and put in heavy benches, vise, pipe vises, shelves, anvil, drill press and emery wheels. More equipment may be added from time to time.

Install soot blowers if possible. Have a bypass around each steam trap.

Keep everyone constantly on the alert and on watch for improvement of service or efficiency. Do not let the men get into the habit of being satisfied with the condition of things as they are. Remember the old saying that the difference between a rut and a grave is only a matter of dimensions.

Electric Elevator Machinery—Elevator Cables, Their Care and Inspection

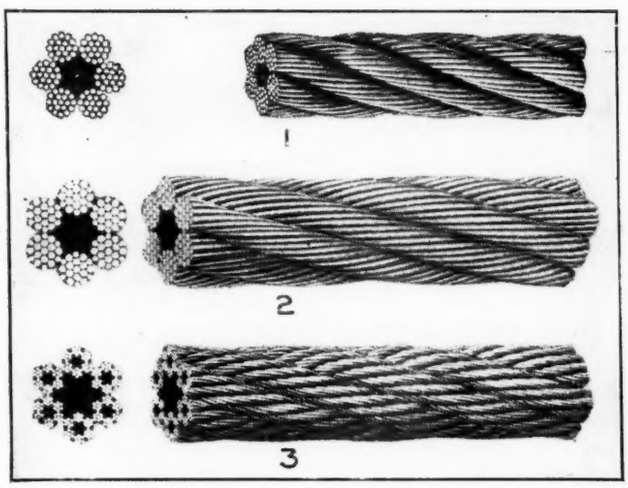
By M. A. MYERS
Electrical Engineer, The Maintenance Company, New York City

WIRE rope used for cabling elevators is of the class ordinarily known as 6 x 19, which means 6 strands, each composed of 19 wires. The strands are wound about a hemp center, which adds little or nothing to the strength of the rope, but acts as a cushion to maintain the shape of the cable and reduces frictional wear betwwen the strands. The size (diameter) of a cable for a particular service is determined by the tensile strength, using in general a factor of safety of 8 to 14 for passenger elevators and 6 to 12 for freight elevators.

High-grade soft iron and mild steel are the materials composing the ropes, the steel having approximately double the strength of iron. Iron rope is used almost exclusively for car and counterweight cables of drum-type elevators, while steel is considerably used for traction elevators where a multiplicity of smaller, lighter and stronger cables are desired for greater tractive effect, and the starts and stops are likely to be more abrupt owing to the nature of the machine.

Fig. 1 shows a 6 x 19 one-size wire cable, where the separate wires are of uniform gage. The strands are composed of six wires wound about the seventh, around which are wound twelve more wires, nineteen in all. Six of such strands are then twisted about the hemp core. The wires of the strands are twisted in one direction, while the strands are twisted in the opposite direction, making what is known as a "regular lay" rope.

Fig. 2 is a 6 x 19 three-size-wire cable, otherwise known as the "Warrington" construction, frequently



FIGS. 1 TO 3. TYPES OF ELEVATOR ROPE

used for elevator work. The strands consist of six large wires wound about a seventh large one, these being surrounded by twelve alternately large and small wires. This construction gives a truer circle and greater wearing surface.

Fig. 3 is a form of tiller-rope construction, of a large number of small wires, which is extra flexible for elevator hand ropes in mechanically or semi-mechanically operated machines and runs over sheaves of small diameters. It consists of six ropes about a hemp center, each rope being composed of six small strands of seven small wires wound about a hemp core, making 252 wires in all.

The amount of wear obtained on elevator cables depends upon the speed at which they travel, the size of the drums and sheaves, the number of bends, the

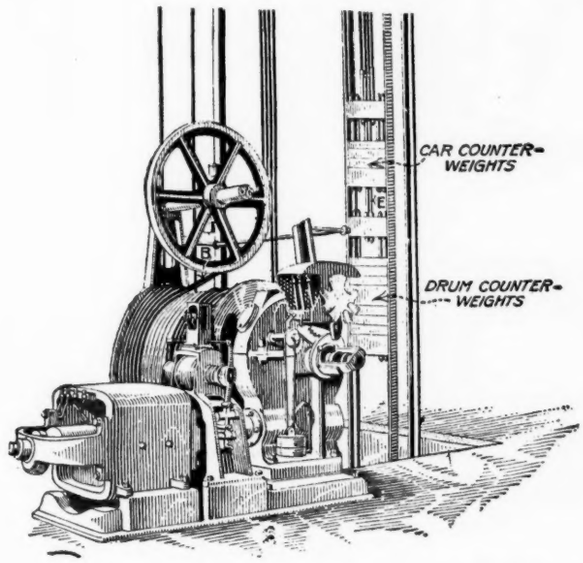


FIG. 4. BASEMENT-TYPE ELEVATOR MACHINE

methods of socketing, the ease or harshness of starting and stopping, care received, etc. It is desirable to have the motor start slowly and accelerate gradually, and the brakes adjusted to stop the car smoothly, with little or no rebound. Drums and sheaves should be of the largest consistent diameters. Such diameters should never be less than 38 to 40 times the cable diameter. The grooves and drums of sheaves must be smooth and correct in size for the particular size of rope used. If multiple grooved drums or sheaves are not grooved to identical diameters or if some of the grooves become worn, excessive wear to cables results. In drum machines it takes the form of unequal loading of cables working in pairs. The fault is exaggerated in traction machines. To illustrate, if one of the grooves of a traction sheave happens to be smaller in diameter than the adjacent grooves, a turn of the sheave will not wind an equal length of cable in the short-diameter groove as in the long-diameter grooves, and the cable must slip to keep up to its companion cables. An apparently insignificant difference in diameters may cause several inches cable slip each car run.

Reverse bends, such as at *B*, Fig. 4, are to be avoided where possible, but they are necessary on basement drum machines for the back drum-counterweight cables passing under the vibrator sheave. Such bends, first one way and then the opposite in rapid sequence, are particularly hard on cables, it being frequently neces-

sary to renew such cables four to six times as often as the more direct hoisting cables.

Wire rope must not be handled like hemp rope, and kinks or near kinks must be strictly avoided. In installing ropes that come in coils the rope should be stretched full length on the ground by unrolling the coil like a wheel. Before cutting a cable, it must be tightly bound with a number of turns of iron binding wire on each side of the proposed cut, to avoid the "unlaying" of the strands and the attendant "high strands" while in operation.

The lubrication of wire ropes is often neglected, which ought not to be the case. A good, non-acid,

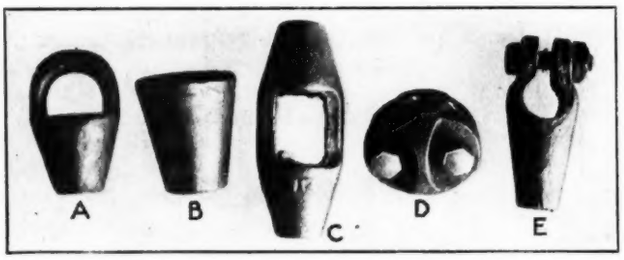


FIG. 5. ELEVATOR-CABLE ACCESSORIES

medium-heavy oil that will both penetrate to the core and also stick to the surface of the ropes is desirable and will lengthen the life of the cables by minimizing inward and outward friction, chafing of wires and by prevention of rust.

Fig. 5 shows several cable accessories, *B* being a plain socket, or basket, or rope-end thimble, as severally called; *A*, a closed socket; *E*, an open socket; *C*, a double-end connector; and *D*, a stop ball. Favorable socket or basket dimensions are: Length, four times the cable diameter; large diameter, three times the cable diameter; clearance of small end over cable, one-sixteenth inch.

A method of socketing a cable ordinarily used by elevator construction and repair mechanics is shown in Fig. 6. The socket is slipped over the cable, large end last, as at *B*. The cable is then tightly served with binding wire a distance from the end equal to the length of the socket plus 2½ times the diameter of the cable, as at *D*, after which the end serving is removed and the six strands are fanned out as far as the remaining serving. The hemp center is cut away, and each strand is bent back and inward on itself, bringing the ends close to each other in the center, and the socket is pushed up tightly over the upset end. Care must be exercised to make the bends of the strands as even as possible and to avoid driving one or more of the strands further into the socket than others, as such a procedure may result in what is known as "high strands," and abnormal wear develop. The small end of the socket is then plastered with fireclay or wrapped with waste and tape, to prevent the escape of molten metal, and melted babbitt, heated just sufficient to char a pine shaving, is poured into the large end of the socket.

The babbitt does not necessarily solder or alloy with the cables, but merely fills the crevices between socket and cable and between the strands, acting as a binder to hold the various parts in place, making a reliable piece of work which will not pull out. Fig 6*A* shows such a job with the socket removed, and Fig. 6*C*, a similar job sawed through lengthwise.

A method of socketing advocated by several cable manufacturers was detailed in *Power* of July 20, 1920, being a paper read by W. Voigtlander, of the John A. Roebling's Sons Co., before the American Society of Safety Engineers. The method is as follows:

The cable is served the length of the socket from the end, with two extra servings below this, and the hemp center removed as far as the first serving. Each wire is separated from its neighbors and cleaned with kerosene, dried and then dipped into a solution half and half muriatic acid and water, and shaken dry. The socket is slipped over the cable and the separate wires are fanned out equally in the basket. Fireclay is placed about the small end of the socket and molten spelter (pure zinc) is poured into the basket. This produces a splendid job, the zinc alloying with the wires of the cable, making a very homogeneous mass in the socket. Knowing the conditions under which most elevator cable socketing is done, the writer prefers to ride in cars where the turned-in method is used.

Rules for deciding when a cable is sufficiently worn to require renewing are not easily given. A rope working under severe conditions, heavy loading, reverse bends, etc., must be discarded when it reaches a state that under more favorable conditions would allow it to be kept in service several months longer. Experience and judgment give the inspector his cue. An ordinary rule followed by many inspectors is, under average conditions, to condemn a cable when as many as five contiguous wires in a strand are broken. "High strands" are indicated when worn spots appear at equal intervals along the cable.

Repair men and estimators who have considerable cable measuring to do, usually have their own particular system, devised to save time and to avoid interference

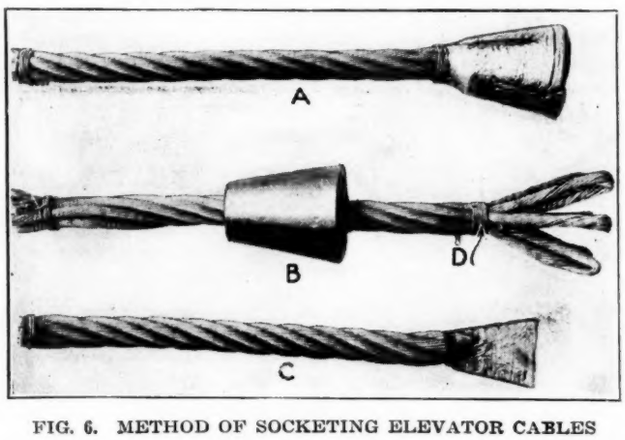


FIG. 6. METHOD OF SOCKETING ELEVATOR CABLES

with service. A method given here has been proved to possess merit. The one measuring the cables sizes up the equipment and draws a rough sketch. Assuming a basement drum-type machine, the sketch will be similar to Fig. 7. He then goes to the overhead works and takes the following measurements in order: *A*, the distance between the lowest sheave center and the top floor by dropping a tape line through the grating; *B*, between the same sheave center and the next higher sheave center. If the drum-counterweight cables run over two sheaves, the turns are considered as if square, as shown, and the distance *C* between the last-mentioned sheave center and the top of the two sheaves is taken. Then *D* the distance between the far circumference of

the drum-counterweight sheaves, and *E*, between the *A* sheave center and the governor sheave center, are taken. *F*, *G*, and *H*, sheave diameters, are measured. Then *I*, the distance between the *A* sheave center and the car counterweight header, is obtained with the car at the bottom floor. The estimator then goes to the top floor and drops a tape line down the hoistway, and with the aid of the operator measures the distance *J* between the top and bottom floors, in relays if necessary. He

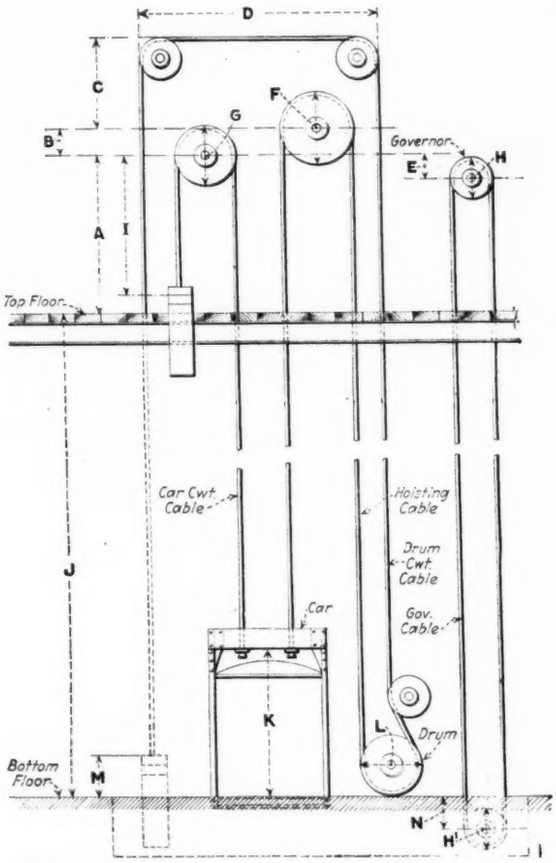


FIG. 7. DIAGRAM FOR CABLE MEASUREMENT

then goes to the basement and obtains *K* the height of the car, the drum diameter *L*. The distance *M* between the drum counterweight header and the floor is taken with the car level with the top floor. Distance *N* from the bottom floor to center of the governor weight sheave, and *H*, the sheave diameter, are determined. The one measuring the cables is then ready for his departure and can afterward do his figuring at his leisure. Thus:

All dimensions are expressed in feet and the drum diameter is multiplied by seven, which gives sufficient cable for the extra wraps. The sheave diameters are multiplied by $1\frac{1}{2}$, which approximates multiplying by $\frac{1}{2}\pi$, giving the semicircumferences. Then:

Hoisting cables, length in feet $= (7 \times L) + J + A + B + (1\frac{1}{2} \times F) + B + A + (J - K)$

Drum Cwt. Cables, length in feet $= (7 \times L) + J + A + B + C + D + C + B + A + (J - M)$

Car Cwt. Cables, length in feet $= (J - K) + A + (1\frac{1}{2} \times G) + I$.

Governor Cables, length in feet $= [(N + J + (A - E) + (1\frac{1}{2} \times H)] \times 2$

The Pit River Project

Good progress has been made on the several plants of the Pit River hydro-electric project in Northern California, the work having been carried on without interruption in spite of bad weather. The first plant in the series, Hat Creek No. 1, was completed and put in service Aug. 1. Work has also been under way simultaneously on two more plants, Hat Creek No. 2 and Pit River No. 1. Plants lower down on the river, Pit River Nos. 2, 3 and 4, are being given further study, consisting of borings at dam sites, comparisons in cost of length of conduits and height of dams, etc., and will probably be constructed in their numerical order.

The complete series of plants contemplated on this stream is expected to add about 600,000 hp. (installed capacity) to the company's system. This amount of energy is estimated to be enough to take care of load-demand increases for a period of eight to ten years. The development program is being held out so that construction will be continuously under way during this period, the plants to be completed as required.

Features of this development will be the 220,000-volt transmission line, the 7-mile, 3,000-sec.-ft. tunnel on Pit River No. 5 and the 40,000-hp. reaction turbines under 454-ft. head in Pit River No. 1. The relative positions of the plants are such that only about 21 miles of conduit was required for serving all seven plants. The flow of the Pit River is so uniform that no storage has been provided for any of the plants thus far built and only very low diversion dams are required.

DETAILS OF FIRST THREE PLANTS, PIT RIVER PROJECT

		Hat Creek No. 1	Hat Creek No. 2	Pit River No. 1	
Static head, ft		216.8	201.3	454.0	
Normal flow, sec.-ft.		400	600	1,400	
Normal output, h.p.		7,900	10,200	60,500	
Conduit	Type	Open Ditch	Flume	Canal	Tunnel
	Length, ft.	2,750	4,469	1,150	10,111
	Size	17 ft. bottom 9 ft. depth	16 ft. 3 in. bottom 7 ft. 0 in. depth	50 ft. bottom	Horseshoe 13.5 high
Number units		1	1	2	
Type wheel		Vertical turbine	Vertical turbine	Vertical turbine	
Manufactured by		Wellman-Seaver-Morgan	Wellman-Seaver-Morgan	Allis-Chalmers	
Capacity, hp.		15,000	15,000	40,000	
Generator manufactured by		G. E. Co.	G. E. Co.	Allis-Chalmers	
Capacity, kva.		12,500	12,500	35,000	
R.p.m.		225	225	257	
Voltage		6,600	6,600	11,000	
Exciter type		Sep. impulse wheel	Sep. impulse wheel	Direct connected	

About 1,500 men are now employed in the camps of the Pit River Basin, working on tunnels, railroad, power houses and other phases of the development, and about 400 men are engaged in constructing the 220,000-volt transmission line. This line is now being built from Pit River No. 1 to Vacaville, a distribution center 205 miles from the Pit River plant and about 60 miles (via transmission line) from San Francisco Bay. The line is to be finished by July 1, 1922, as is also a $1,250,000 substation at Vacaville.

Power for construction purposes was developed in a temporary plant near the junction of Fall and Pit Rivers, about ten miles from Hat Creek No. 1 and three miles from Pit River No. 1. Here the head and flow available were suited to an old 1,000-hp. unit which the company had in a generating station at Folsom. This unit was accordingly "loaned" to the Pit River project until the first plants there should be in service.

The Pit River project is being carried out by the Pacific Gas and Electric Co., of San Francisco. O. W. Peterson, construction engineer for the company, is in charge of the work on the projects.

Throttle Valves for Steam Engines

By W. H. WAKEMAN

A TYPE of throttle valve that is found on many steam engines is shown in Fig. 1. The first impression is that it causes more friction of the steam passing through it than a globe valve, but an examination of the internal design demonstrates that this is not correct. The turn caused by the connected

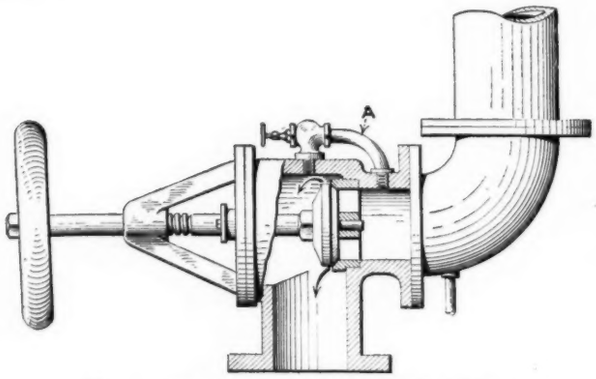


FIG. 1. THROTTLE VALVE WITH BYPASS

ell is also found in the globe valve, and otherwise the valves are alike.

This valve opens the instant that the wheel is turned toward the left, because steam pressure acts against the face of the disk, thus taking up instantly all lost motion in the parts. While the valve is closed, hot water resulting from the condensation of steam, may gradually leak past the disk, as shown by the lower arrow, until a small channel is cut through at this point, thus causing a leak that cannot be closed by forcing the valve to its seat. Regrinding is the only remedy.

The same type of valve may be fitted with a bypass *A* which proves convenient in service. The cylinder of an engine should be heated gradually before the flywheel is given a revolution, and in order to do this, only a small quantity of steam can be used. When admitted by an ordinary throttle valve, it must come through a small circular opening, hence the true surface is soon destroyed, resulting in a leaky valve. If the lubricator is started before the throttle valve is opened the steam will be saturated with oil and it will be less liable to cause a leak, but the objectionable feature will not be eliminated.

With the bypass shown, the small valve may be opened to its full capacity without causing trouble, hence the steam will not be wiredrawn while warming the cylinder, and in some cases the engine may be run at low speed by it. When the bypass is closed, the main valve may be opened to about one-quarter capacity at first, after which it is opened wide and the wiredrawing action is eliminated.

These valves must be connected as shown, because the steamfitter is not given a chance to choose, but Fig. 2 is a globe throttle valve that may or may not be placed so that the steam pressure will act against the face of the disk. When so located, the threads on the stem must carry the full load when the valve is closed. With a 6-in. valve under 100 lb. pressure this amounts to over 2,800 lb., which explains the constant tendency to leak.

On one occasion a throttle valve was adopted that was fitted with a hard-rubber disk, and it was expected to repair it without the tedious process of regrinding; but it was found to act as an expansion steam trap, keeping the cylinder hot all night and reducing the boiler pressure accordingly, as it was connected as shown in Fig. 2.

Had it been reversed, as illustrated in Fig. 3, this annoyance would have been avoided, because the steam pressure would have held the disk to its seat. The disadvantage of this plan is that when the wheel is turned to the left hand, the disk is not started from its seat until all lost motion is taken up by the pull of the stem. There is a heavy weight on the disk at this time, and as soon as steam passes the disk and pressure begins to increase on the face of it, all lost motion is quickly taken up in the opposite direction, hence the valve may be opened wider than is desirable. If the disk is accidentally disengaged from the stem, it will not

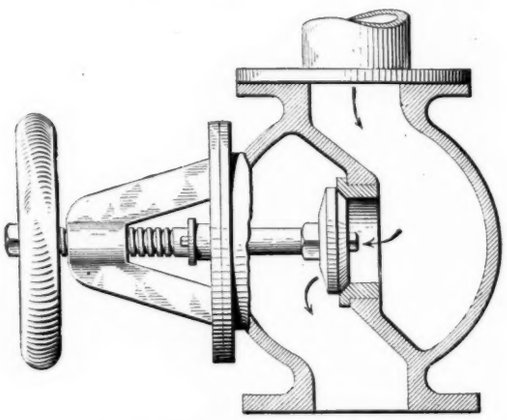


FIG. 2. STEAM ACTS AGAINST VALVE DISK

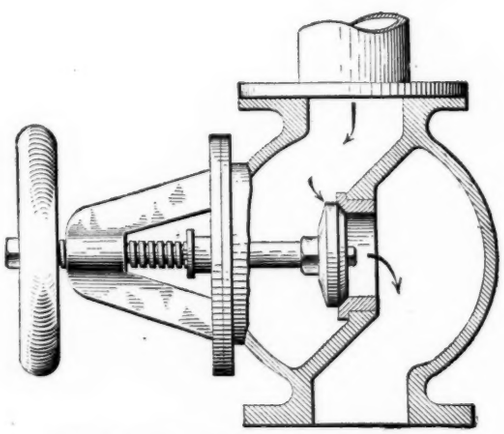


FIG. 3. STEAM HOLDS DISK TO SEAT

be possible to open the valve until it is relieved from pressure and repairs are made, but this is not likely to happen.

One of the engines in my plant is fitted with the design of throttle valve illustrated in Fig. 4. For 19 years this valve was in service and was then displaced by a larger one of the same kind. As steam acts on top

of the disk, it is always held to its seat automatically, hence it has never leaked, and its record is satisfactory in every other respect. The stem of this valve was packed with asbestos eight years ago and has not leaked steam since. It has leaked a few drops of water on

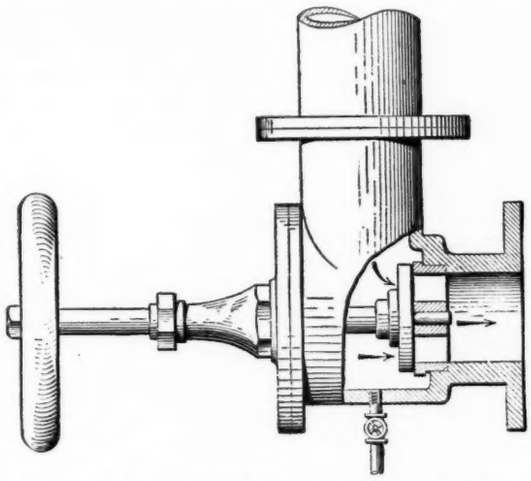


FIG. 4. AN ANGLE-TYPE THROTTLE VALVE

several occasions, but a slight tightening of the packing nut was sufficient to make it tight, and the wheel always moves easily when opening and closing. The reason for this satisfactory service is because the valve is always under boiler pressure, hence is not affected by changed conditions in this respect. This is not a theory but a condition.

Fig. 5 shows a throttle valve that is favored by some engine builders, and while it has good features it is not perfect. As it is of the gate type, it is always held to its seat by boiler pressure when closed, hence there is no need for forcing it in as far as possible by a leverage on the wheel. This point is mentioned because

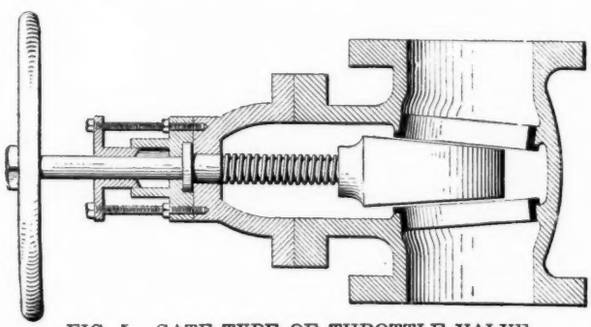


FIG. 5. GATE TYPE OF THROTTLE VALVE

some engineers consider it necessary to use a wrench or a piece of pipe to secure extra leverage to close every kind of valve, including those that are fitted with hard-rubber disks. This type of valve has been discarded in some plants, because the disks do not prove durable under such abusive treatment.

With some of the valves that are illustrated by Fig. 5, it is necessary to give the wheel two revolutions in order to admit steam enough to warm the cylinder, and the gate moves slowly for the remainder of its travel. This naturally prevents it from being opened too quickly, but it also requires a long time to close it. Under ordinary conditions this is no special disadvantage, but if an engine begins to race (and it is not fitted with an automatic stop motion), the delay of a few seconds in closing the throttle valve may prove disastrous.

Fig. 6 illustrates a type of gate valve for controlling small engines requiring a 3-in. steam pipe, or less. The stem has no threads, but slides through the stuffing box without turning. Such a valve must be handled cautiously, as it gives a very quick opening and can be

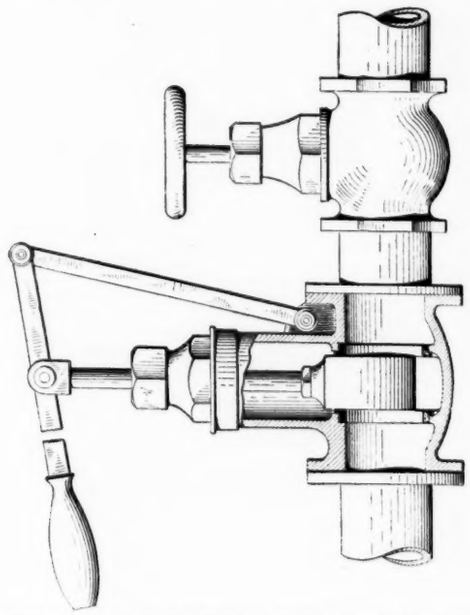


FIG. 6. QUICK-OPENING THROTTLE VALVE

closed at the same rate. It is suitable for hoisting engines, etc., where great variations in speed are required. There should always be a globe valve just above it, for shutting off the steam while the engine is not in service.

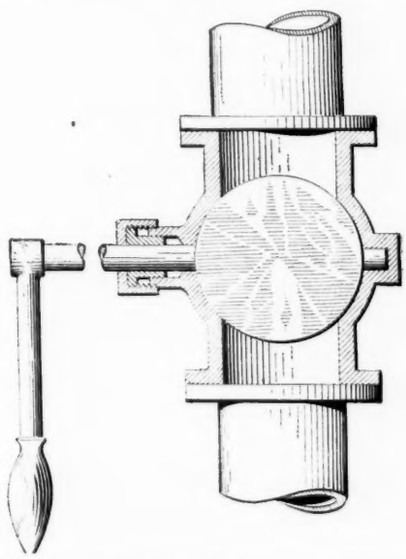


FIG. 7. BUTTERFLY TYPE OF VALVE

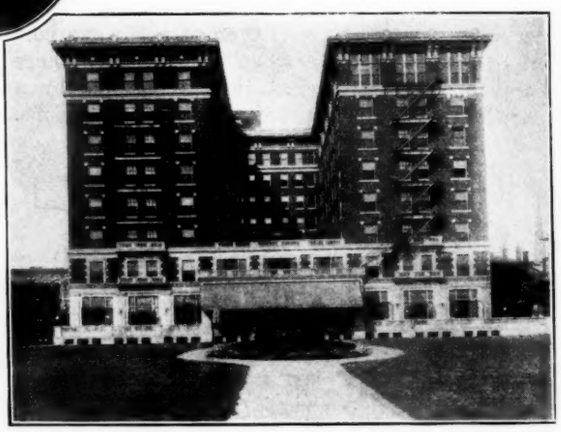
Fig. 7 illustrates another form of quick-opening valve, which is known as the butterfly type. The stem turns only through one-half revolution or less. It is made in sizes up to 16 in., which is practical in service because it is perfectly balanced. It is not intended for an absolutely tight shut-off. A globe valve should be located above it.

Thirty-Ninth Annual Convention
National Association of Stationary Engineers

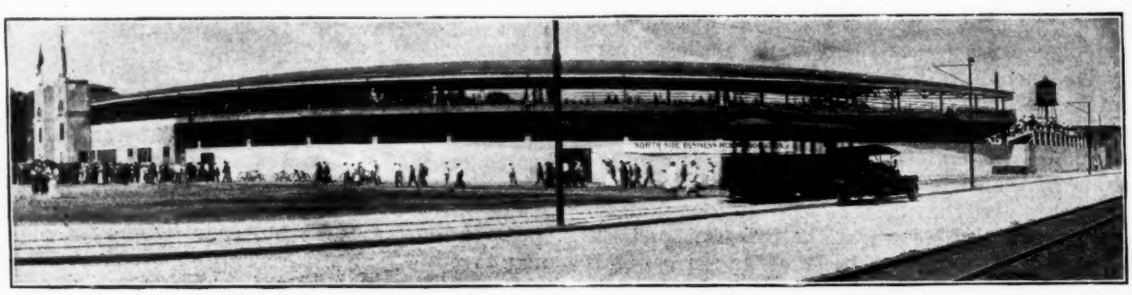
Evansville, Indiana — September 12-16, 1921

The local convention committee, in charge of preparations for the event. From left to right the members are: Back row, Henry Welz, Gustav Weber, Charles Streithof (chairman), Louis Minke, Charles Boos; Front row, G. C. Bruner, W. G. Baechle, E. G. Heeger, Carl Dreisch. Mayor Bosse of Evansville (in oval) is an ex-officio member, and is chairman of a committee of citizens that is helping to boost the convention and help with the arrangements.

The Soldiers and Sailors Memorial Coliseum, which will house the exhibits and the business meetings.



The Hotel McCurdy, which will be the headquarters of the delegates and visitors to the convention.



Bosse Field Stadium, at Garvin Park, where the field-day games will be held.

Overhauling an Oil Engine

By G. GROW

LATELY I was called upon to overhaul a Diesel oil engine that had been in service for some time and then sold and installed in another location. This engine, upon starting, had never operated satisfactorily. For some reason it pounded badly, smoked considerably and refused to carry over one-quarter of its rating.

On first visiting the plant, I requested the engineer to start it so I could see how it ran. The engine turned

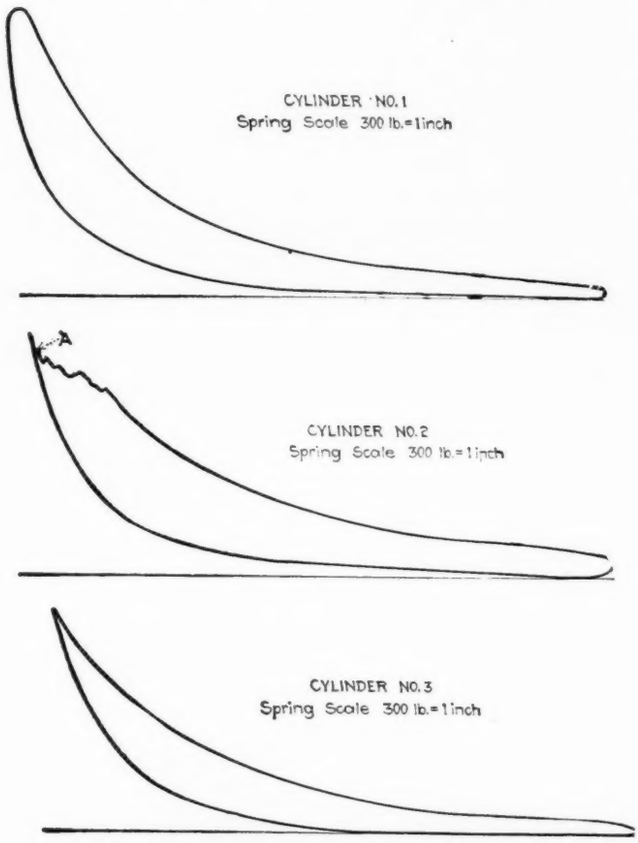


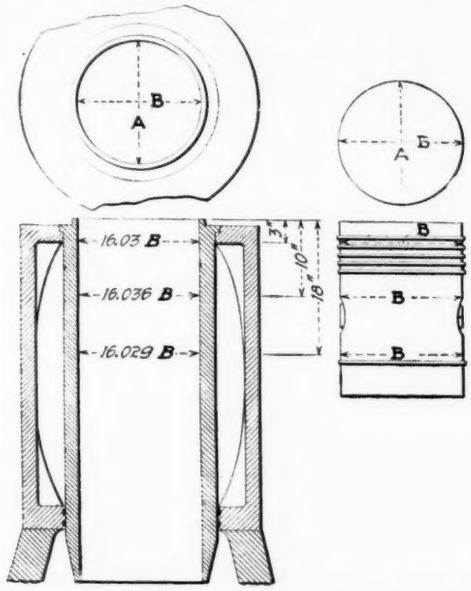
FIG. 1. INDICATOR DIAGRAM SHOWING FAULTY COMBUSTION

over and began firing on two cylinders, although in No. 2 cylinder the firing was weak. The third cylinder refused to fire at all, and each time the admission or suction valve opened, a dense black cloud of smoke blew out of the suction pipe. After having the engine limp along a few minutes, the engineer shut it down and we started to discover the peculiar action of the third cylinder.

The cams that originally had been on the engine had become worn and had been replaced by a new set. In making the change the engineer had, through error, switched the suction and exhaust valve cams, and as a result, when the engine started the suction valve on the No. 3 cylinder opened at the end of the firing stroke, allowing the gases to blow out into the room; the exhaust valve opening on the suction stroke caused the engine to draw in a charge of burnt gases from the exhaust manifold. Of course this gas, when mixed with the fuel charge, would not burn. The trouble was remedied by placing the cams in their proper position.

To determine why the No. 2 cylinder fired so weakly, the engine was started again and an indicator was attached to each cylinder in succession, and the diagrams appearing in Fig. 1 were secured. The diagram from No. 1 cylinder is good, although the compression pressure was somewhat low, being only 430 lb. A study of the diagram from No. 2 cylinder reveals at first glance why the firing was weak. The fuel is not ignited when the piston is on top dead center, the combustion beginning at *A*. The late ignition caused the exhaust pressure and temperature to be very high, which warped the exhaust valve, as afterward discovered.

To account for this late combustion without a close examination of the engine, two reasons could be advanced. If the fuel valve opened late, of course the combustion would be delayed. On the other hand, the interval of time elapsing between fuel injection and



CLEARANCE MEASUREMENTS

Distance from Top, Inches	Cylinder Measurements		Piston Measurements	
	A	B	A	B
3	16.025	16.020	15.975	15.980
10	16.030	16.029	15.980	15.982
18	16.029	16.019	15.975	15.982

FIG. 2. METHOD OF MEASURING CYLINDER WEAR

ignition depends upon the compression carried. With the low compression in this cylinder the delay in combustion could have been due to a longer time interval than usual. However, in this particular instance, upon checking the timing of the fuel valve it was found that the fuel needle valve did not open until ten degrees after dead center. The low compression in No. 3 cylinder was due either to piston wear or an excessive clearance space between piston and cylinder heads—this could be determined only by examination.

Since an overhauling was necessary or at least appeared advisable, the cylinder heads, piston and all valves and cages were removed and thoroughly cleaned.

The piston and cylinder were measured with micrometers to determine the side clearance. Notations of the measurement atop, middle and bottom of both piston and cylinder were made on a sketch as shown in Fig. 2. This enabled us to determine at once if the wear was such as to require reboring of the liner and a new piston. The dimensions marked *A* were taken at right angles to the engine center line, while the *B* measurements were taken parallel to the crankshaft. The greatest clearance found was 0.055 in. at right angles to the shaft. This, while large, was not enough to justify the reboring or replacement costs as long as it was possible to obtain the proper compression. The rings were worn a considerable amount and new ones were fitted to each cylinder, a gap clearance of 0.01 in. being allowed.

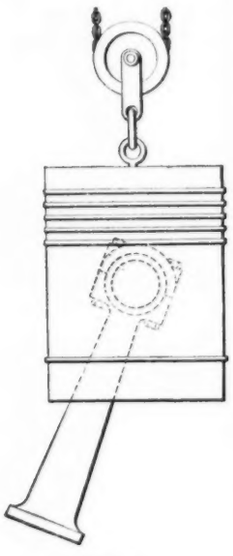


FIG. 3. CHECKING PISTON-PIN CLEARANCE

The piston-pin bearing on each rod was adjusted and the slackness taken out. While some engineers use a lead or fuse wire in the bearing, drawing the bolts up until the two bearing halves are tight and then removing the leads to measure the clearance between pin and bearing, this is not absolutely necessary and a much easier plan was adopted, since it was necessary to get the engine back into service. The pistons were hung from the chain hoist and the connecting rod swung as in Fig. 3. If a man could barely swing the rod without tilting the piston, the piston-pin bearing had ample clearance. If no great effort was required to swing the rod, the pin was too loose and a shim was removed. By following this method proper running clearance was secured without any micrometer measurements.

Both the crankpin and piston-pin bearings were scraped to a good fit on the pins. On two of the crankpin bearings the side clearance was excessive and consequently a ring of tin solder was run on each side and faced off square with the cap of the bearing to give 0.008 side clearance. Fig. 4 illustrates the method followed. In facing the ring extreme care was exercised in setting the bearing on the lathe or drill press. In this case we used a drill press and bored a plate to go on the drill-press table to hold the lower end of the boring bar. The bar was made of a piece of scrap shafting slotted for the facing tool with the end reduced to fit the spindle.

In operation the engine pounded badly at one of the crankpins. The engineer claimed that even though this bearing fitted so snugly as to cause excessive heating, the pin still pounded. As a consequence a micrometer was used in measuring the crankpin and it was found to be a trifle flat, being 0.003 in. out of round. The proper procedure would have been to ship the shaft to a machine shop and have the pins ground true. Lack of time prevented this and to avoid excessive bearing clearance and pounding, we decided to try to lap the pin. To do this a light brass shell having a diameter 0.002 less than that of the crankpin was cast and machined at a neighboring machine shop. This lapping shell was made in halves, being provided with flanges for bolting together. The inside surface of the shell was slotted to hold emery compound. Sufficient shims were inserted between the two shell halves to allow it to go on the pin. By rotating the shell back and forth, reducing the amount of shims as the pin was reduced, the crankpin was finally brought to almost a true circle, a flat of about one-half a thousandth still existing. This was the first time any of the men had ever attempted a pin-lagging job, and it entailed as much work as the balance of the overhauling. The crankpin bearing was then scraped to the new pin surface. The job was a success as far as could be determined. Fig. 5 is a sketch of lapping shell used.

When the engine was running, the crankshaft always had a decided lengthwise shift, the end of the shaft moving in and out as much as $\frac{1}{8}$ in. This was undoubtedly caused by one or more of the bearings being low. After the removal of the pistons and rods the shaft was relieved of all save its own weight. By using a special shaft spirit level it appeared that the shaft, when free, was level. Measuring with a gage from the machined edge of the housing to the shaft surface, as illustrated in Fig. 6, also seemed to prove the alignment. Unfortunately the housings for the lower bearing shells had not been bored to a test bar and the lower shells were not all of equal thickness. This prevented us from determining the alignment of the lower shells. The

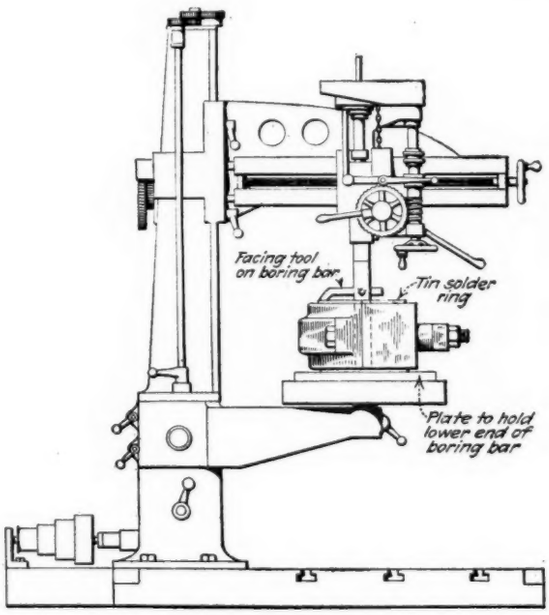


FIG. 4. FACING CRANKPIN BEARING

shaft shifting denoted misalignment, but the question arose as to how to align the shaft bearings without removing the 10-ton flywheel and lifting the shaft, since no lifting jacks were available. The suggestion was made and adopted that each journal be lightly coated with prussian blue, and then by revolving the shaft any journal lower than the others would not wipe the prussian blue. This proved to be practical and we found the two inside bearings to be entirely out of contact with the journals. Either of two methods of repair could be followed—the low bearing could be raised by shimming under them, or the high bearings could be removed and scraped. The latter course was adopted since a shim under a bearing is always inadvisable. By aligning the lower bearings we knew that, when

loaded with the piston weight and the cylinder pressure, the shaft would not be able to bend.

We now started to reassemble the parts, the first step being to give the correct clearance to the crankpin bearing; this we made 0.007 in. by using leads or fuse wire to measure the clearance when the two bearing halves

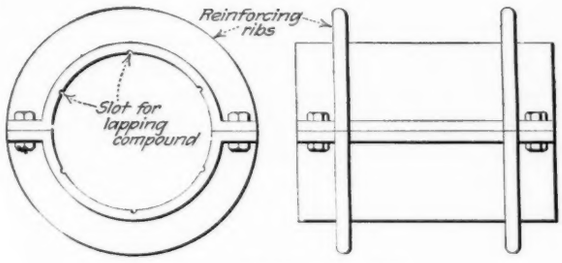


FIG. 5. CRANKPIN LAP

were bolted together. After giving the correct clearance, the bearings were very stiff and the men felt sure the pin would grip the shells. However, a few shots of oil into the bearings made them work freely and the engine could be barred over by one man.

After the piston and rods were replaced, the valves and cages were gone over, all being nicely ground. The fuel needle valves were badly corroded due to the packing being too tight. New needles and new packing were used. The fuel pump was then overhauled and the valves ground. The air compressor was next taken apart and the intercooler coils found very gummy. By inserting a steam hose, the oil gum was fairly well blown out. What remained was worked out with a 50 per cent muriatic-acid solution. We found the engine water jackets badly scaled, the water used being very hard. Acid was used to clean the jackets and a new cooling system installed, which will be described later. On completion of the work the engine was started and one cylinder pounded badly. This was found to be due to a slight discrepancy in the widths of the crank gap

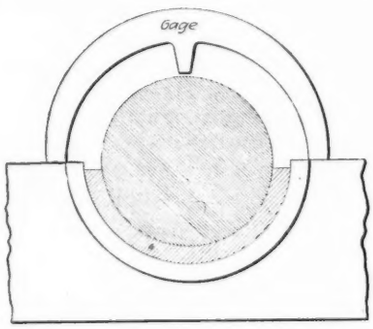


FIG. 6. SHAFT-ALIGNMENT GAGE

at the pin and at the shaft. Since we had decreased the side clearance of the crank bearing, the bearing jammed against one side as the engine turned over. It was necessary to increase the side clearance to stop the pound. With this and a few minor adjustments the engine ran very nicely.

In the engine as erected the cooling water was taken from a small stream or mill-race and after passing through the engine was discharged into the stream. As already stated, the water was hard and a distilled-water inclosed system was installed. With this system a series of pipe coils similar to the ordinary ammonia atmospheric condenser was installed—in fact this is what we bought, using two 12-pipe stands of 2-in. pipe, each coil being 20 ft. long. The system was first filled with water from the stream, and since the same water was used over again the amount of scale from the original water was practically negligible. Fig. 7 is an outline of the system as installed. A 3,000-gal. steel tank was mounted on a low scaffolding on the roof of the plant. This tank was covered to avoid evaporation loss. The cooling coils were also located on the roof and discharged into the tank. The water from the tank entered the engine jackets and after performing its mission flowed into a concrete sump inside the engine room. A reciprocating pump picked it up and forced it through the cooling coils or condenser and then into the overhead tank.

A piston pump was selected in preference to a centrifugal pump to avoid danger of loss of suction. The raw water that was sprayed over the coils was handled by a centrifugal pump, and after cooling the jacket water flowed back into the river. This system or modifications of it an coming into general use. It is customary to allow two square feet of coil surface per brake horsepower with a temperature difference between the inlet

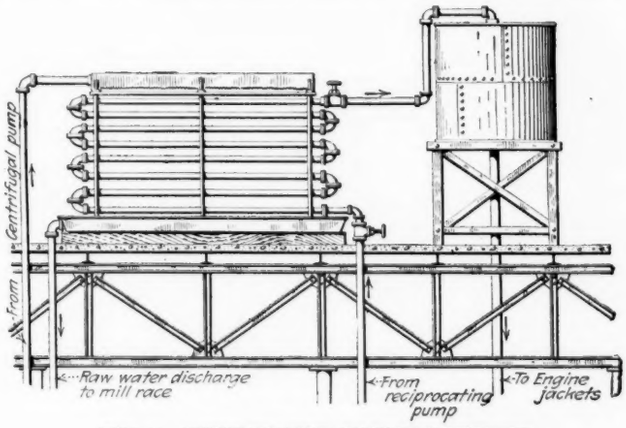


FIG. 7. PURE-WATER COOLING SYSTEM

and discharge cooling water of 40 deg. If the temperature of the cooling water is high, a greater pipe area is necessary and the quantity of raw cooling water must be greater. If the raw water contains considerable foreign matter, it is necessary to keep the coil surface clean by scraping.

Hydro-electric development is one of the livest topics of the day in Europe, according to Frank B. Jewett, chief engineer of the Western Electric Co., who was a member of the John Fritz delegation that recently visited England and France. He reports that extensive plans are being made, but that little can be done until the financial situation clears up. In England there is a good supply of coal, but little water power, so that the subject is not of such great importance there. In other countries, however, especially in Scandinavia, the matter is one of intense interest. It has been suggested that Norway, Sweden and Denmark might well be electrically interconnected, in many cases by submarine cable, which is even now being used to carry power to Copenhagen.

Steam Traps—Types, Principles of Operation, Selection, Installation, Troubles, Remedies

By L. A. H. MERRIHEW

IN THIS DISCUSSION of steam traps no attempt will be made to cover their history, but only to deal with some of the general phases of the subject that are of practical importance rather than with the curios on the shelves of the Patent Office. An attempt will also be made to show the great value to the engineer of a thorough knowledge of the subject of trapping.

Without referring to a mechanical dictionary for a definition, it may be said that a steam trap is a device

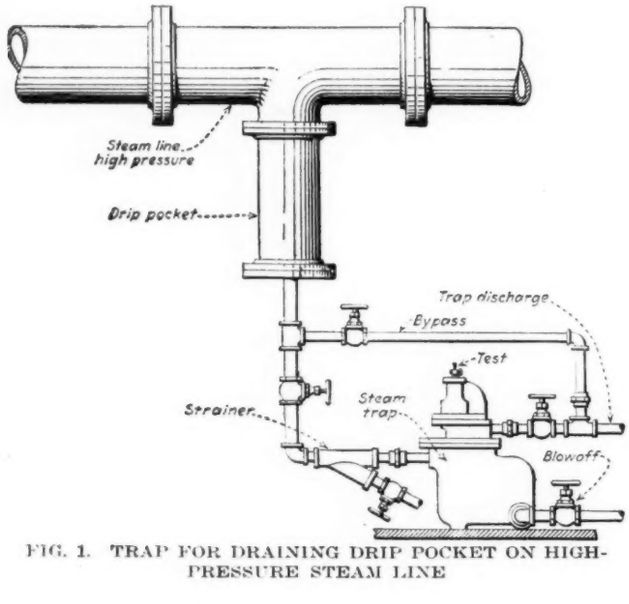


FIG. 1. TRAP FOR DRAINING DRIP POCKET ON HIGH-PRESSURE STEAM LINE

that automatically removes condensation from any vessel or container under steam pressure without permitting any steam to escape and without loss of pressure. Removing the water as it accumulates is the main function, but retaining the steam without leakage is also essential. Therefore the trapping device should always be thoroughly water-sealed and its valve mechanism absolutely steamtight.

The importance of this feature can be seen from a consideration of the table. This was figured at a time when coal was at its zenith, and a round figure of $10 per ton was used. The reader can easily alter the computation for his own conditions, either as to cost of coal or magnitude of leaks. As a basis of study the loss at various pressures through a hole ⅛ in. in diameter is computed and capitalized at 6 per cent.

Savings by Proper Use of Traps

The table shows the result of discharging through a ¼-in. hole from the given gage pressures to the atmosphere. Note that a loss of $135, under the conditions given at 100 lb. pressure, is a year's interest on $2,250. In other words, a considerable portion of $2,250 could be spent in order to make the saving. Actually, less than twenty-five or thirty dollars would buy any make of good steam trap to take care of such a leak.

The loss due to one small leak is brought out above. The loss due to several of these may run into such amounts as to be a heavy charge against operating expense. But the loss due to the occasional spoiling of a batch of process work may run into hundreds or even thousands of dollars and mean the success or failure of an enterprise.

LEAKAGE LOSS THROUGH A HOLE ⅛ INCH IN DIAMETER IN TERMS OF STEAM, COAL AND MONEY

Flow of steam figured by Napier's Rule, $W = \frac{PA}{70}$, where W = pounds of steam per *second*, A = area of opening in square inches = 0.0123 sq.in. for ⅛-in. hole, P = absolute pressure of steam in pounds per square inch.

Gage Pressure, Lb. per Sq. In.	Steam Loss, Lb. per Hr.	Coal Loss, Lb. Per Hr. (On Basis of 8 Lb. Steam per Lb. Coal)	Dollars Lost per Hour (Coal $10 per Ton)	Dollars Lost per Year of 3,000 Working Hours	Amount This Will Finance at 6 per Cent
10	16	2.0	$0.010	$30	$500
25	25	3.1	.015	45	750
50	41	5.1	.025	75	1,250
75	57	7.1	.035	105	1,750
100	73	9.1	.045	135	2,250
125	89	11.1	.055	165	2,750
150	105	13.1	.065	195	3,250
200	136	17.0	.085	255	4,250

For areas larger than a ⅛-in. hole, multiply above figures by ratio of new area to area of ⅛-in. hole (0.0123 sq.in.).

Amount necessary to crack valve off seat to equal area of ⅛-in. hole:

Valve Size, In.	Amount Open, In.
¼	0.0078
⅜	0.0052
1	0.0039

Though it is not generally recognized, nevertheless that part of practical steam engineering that comes under the head of steam traps, their selection and application, is as important as any other phase of the profession. While an engineer may select his turbine on a guarantee of one-half of one per cent better efficiency, he may be losing two or three per cent through faulty traps or the lack of traps. He may be using the utmost care in his engine and boiler room, but more than waste all this effort through leaky drips or through poor results in process or other production work. This could easily be remedied through due consideration of the question of steam traps.

For example, a certain soap manufacturer required eight or nine hours to boil his kettle of several barrels of soap. Consideration was given to improving the trapping of the steam coils in these kettles, and more than an hour was cut off the boiling time. Not only was production increased, but the cost of it decreased. A large wood-products concern was running several boilers for power and heating dry kilns. They had considerable difficulty in maintaining the required steam output. Eventually, the kilns were trapped and such a saving resulted as permitted the laying off of one boiler. A manufacturer having continued trouble with bad joints in his pipe lines caused by improper trapping and resulting in gasket trouble, spoilage of insulation and disagreeable wet spots, eliminated all his troubles by proper trapping. An engineer, having continual diffi-

culty with water in his engine cylinders and finally knocking out a cylinder head, properly trapped the steam separator in the line and had no further trouble.

These are typical of instances that have come into the experience of all who have studied or followed the steam-trap industry. They serve to support the statement of the necessity for a thorough and expert handling of steam-trap problems. Nothing but steam traps will do what good steam traps will do; and no matter how much one may know about the so-called more important units such as boilers, turbines, stokers, etc., his entire knowledge and effort may be neutralized through a lack of proper understanding of what steam traps will do and how to use them. There are boiler experts, experts with turbines and so on, but the operator wishing to preserve the useful results of his knowledge along these lines should make it a point to become equally expert with regard to traps.

Classification of Traps

The common types of steam traps today may be listed under four headings: Expansion or thermostatic traps; tilting traps; closed float traps; and open-float or bucket traps. In the thermostatic trap the expansion of metal or a contrivance of metal, generally termed the expanding element, is depended on to operate the valve. In the tilting trap the body or receiver is suspended on hollow trunnions that form the ports of entry and discharge for the condensation that the trap handles. As the receiver drops after filling, it operates the trap valve, and then closes this valve as it rises after discharging, being actuated by a counterweight. In the closed-float type the buoyant effect of a float is applied through a system of levers to operate the valve in opening, and the weight of the float is used in closing. In the open-float or bucket trap the weight of the full bucket is used to operate the valve in opening, but its buoyancy, after the bucket is emptied, is utilized in closing.

It will be noticed that the elemental forces used in both the open- and closed-float traps are the same, but that the application in one style of trap is the reverse of that in the other for identical operations. This should be borne in mind in considering these two classes of traps, as it touches their fundamental difference. In these general classes there are various types of traps, each of course reflecting the idea of the designer or producer as to the best application of the principles employed. This article, therefore, will touch on no specific makes of traps, but rather on a few of the prominent features of each class.

Advantages and Disadvantages of Each Type

In the expansion trap, after the trap has discharged, steam comes in contact with the expanding element and raises its temperature, causing this element to expand and close the valve. This expanding element may be a U-tube or a cylinder containing an expansive fluid responsive to temperature changes and actuating a cartridge controlling the valve, or the action may be obtained by the difference in the expansion of different metals. In some cases this action is applied directly to the valve, and in others, through a system of levers, either to increase the area of the valve or to extend its opening. In any case the fundamental fact of expansion and contraction due to temperature changes is the basis of this type of trap.

The expansion trap is considered satisfactory in many places if proper attention is given to keeping it in adjustment. The continued operation of the expanding parts sometimes results in "growth" of those parts, as well as occasional crystallization, necessitating adjustments. This trap is of the constant-flow type and may have a tendency toward wiredrawing or cutting of the valve and seat. However, these parts can, as a rule, be easily renewed.

As pointed out, the expansion trap depends on temperature changes for its operation. Where the trap closes against pressure, no matter how large the accumulation of water coming into it, this will not be taken care of until the trap has cooled sufficiently to open. If several of these traps are connected to a common return, should one become leaky it may let sufficient steam through to work back on the others and keep them closed. The advantages of the expansion trap are that it gives the least trouble with air binding and is unlikely to freeze in severe places if kept properly adjusted.

The tilting type was early in the field and has a receiver capable of withstanding the working steam pressure. This receiver is suspended at the lower part of one end or on an extension from it, through trunnions to which the inlet and outlet connections to the

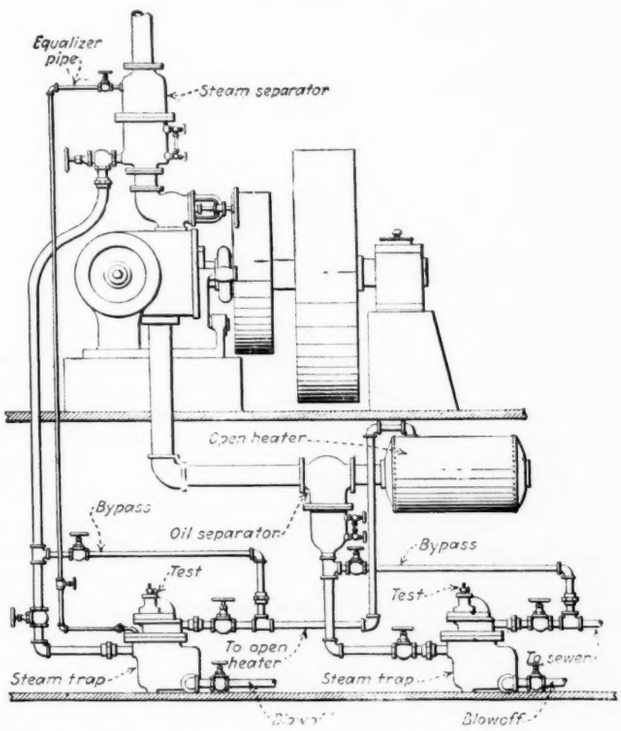


FIG. 2. TRAPPING MOISTURE FROM INLET STEAM AND OIL FROM EXHAUST OF ENGINE

trap are made. The operating valve of the trap controls the inlet and outlet ports. When the receiver has filled with condensation, it drops and opens this valve. When the trap has emptied, the counterweight on the receiver brings it back to the filling position and closes the valve. The functioning of this trap can be readily understood and it opens a good port area. The main difficulties come from the stuffing-box glands on the trunnions. If kept too tight, they impair the trap's operation, causing it to stick. If kept too loose to avoid binding, the

glands leak and cause a steam loss and wear on the trunnion and stuffing-box parts. To keep them properly adjusted is the problem. Altogether, these traps give good service if well attended, but sometimes they require considerable attention.

In the case of float traps the buoyancy of the float operates the valve through a system of levers, and the weight of the float closes the valves through this same system. The valve, with one or two exceptions, is below the water line and, unless protected by a strainer or otherwise, is subject to being "caught" on dirt or scale. In such a case the trap blows empty and steam losses result until the case is discovered. Some float traps are provided with strainers, but these must be kept clean and watched to see that they do not corrode and drop into the trap or become useless and plug it up.

This type of trap is sometimes called a constant-flow trap, as it takes care of the water just as it comes to the trap. A small amount coming in, the float is slightly raised, thus opening the valve a trifle and letting practically an equal amount of water out. Under heavy pressures this action has a wiredrawing or cutting effect on the valve and seat. These traps are most desirable where the apparatus receiving the trap discharge must have this discharge come with steady flow. Floats are

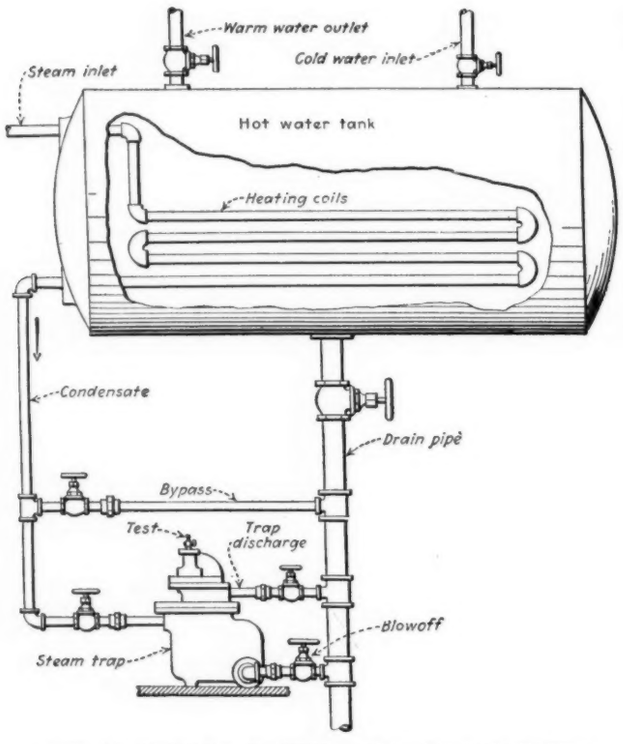


FIG. 3. TRAP ON HEATING COIL OF HOT-WATER SUPPLY TANK

made much better these days than years ago, and manufacturers guarantee them for very high pressures, although there is always the possibility of failure.

In case of the open-float or bucket-type trap there is a hinged bucket suspended in a trap body. As condensation comes into the trap, it finally overflows and fills the bucket, causing it to sink. A discharge tube generally leads from the trap cover down into the bucket. Somewhere in this tube the valve, as a rule, is placed and connected to the bucket by a valve rod. As the bucket sinks, it pulls the valve from its seat, and pressure in the trap discharges the contents of the bucket through the discharge tube to the outlet connection from the trap cover. In this type of trap the valve is wide open while discharging. Thus wiredrawing is eliminated as the trap closes completely after discharging. The open float cannot collapse, but should anything happen to it, it will drop and unseal the trap. This will blow steam until discovered, but will not usually do any harm in the system.

All the foregoing comments are directed at the more prominent features of the various traps as general types. One of the most instructive courses an engineer can pursue is to obtain the catalogs of various manufacturers and study them thoroughly along with the theory of the subject. Many of these catalogs treat the matter from both a practical and theoretical angle in a thorough fashion. If these books or booklets are obtained and the design of and claims for each trap carefully studied and weighed, one point being balanced against another and their worth considered, an engineer can in a short time make himself possessor of the fruit of years of experience, study and development in the trap field.

Causes of Trouble

On the question of steam-trap troubles it may be said that in general they are comparatively few. Occasionally, a lack of acquaintance with the conditions or with the traps may cause some question but the art has developed to the point where manufacturers put thousands of traps into service every year and seldom have a complaint. One of the most common difficulties is that of air binding. We all know that water absorbs air. When this water is converted to steam, the air naturally separates out, but air, being heavier than steam, settles to the bottom of the system or container carrying it. As the trap is always at the low point, the air finds its way there, keeping the water back. As either the tilting, float or bucket traps require water to come in to operate them, they cannot function, so the system is sealed. To get rid of the air, the traps are generally equipped with air cocks.

Air binding is always likely to occur if the trap valve is tight. If the valve is leaky, it will let out not only the air but steam as well. So it may generally be said that air binding is an indication of a tight trap rather than otherwise, and that a trap that leaks air will do the same with steam.

Sometimes, owing to haste or other causes, a trap has the inlet and outlet connections reversed. Sometimes a low-pressure trap is thoughtlessly placed on a high-pressure job. Sometimes traps are overhauled and not reassembled properly. All these things give trouble. It is obvious that a trap must be properly connected up and properly assembled.

As to a low-pressure trap on a high-pressure line, the principle involved in trap design is to make available the leverage from the bucket or float to operate or open the valve against the pressure in the trap. Hence, for various operating pressures the valve area multiplied by the pressure in the trap must be less in pounds than the trap leverage. Therefore it is essential to have the right valve for the given conditions.

One further phase of trap practice seems worthy of mention here—that is, thorough and systematic as well as regular periodic inspection. It is not unusual to find traps installed in some out-of-the-way corner or hole and entirely neglected. In fact, they seem to be for-

gotten. A plant operator would not take the cash from his pocket and throw it away into some corner, but will sometimes do what is virtually the same thing by putting the money into a trap and, after putting the trap in a corner, neglect it so completely that to all intents and purposes the money is thrown away. To simplify the matter of inspection, traps should be installed in accessible places.

One common practice that is more or less of a mistake is the selection of steam traps by pipe size. It should be unnecessary to refer to this at this age and date, but

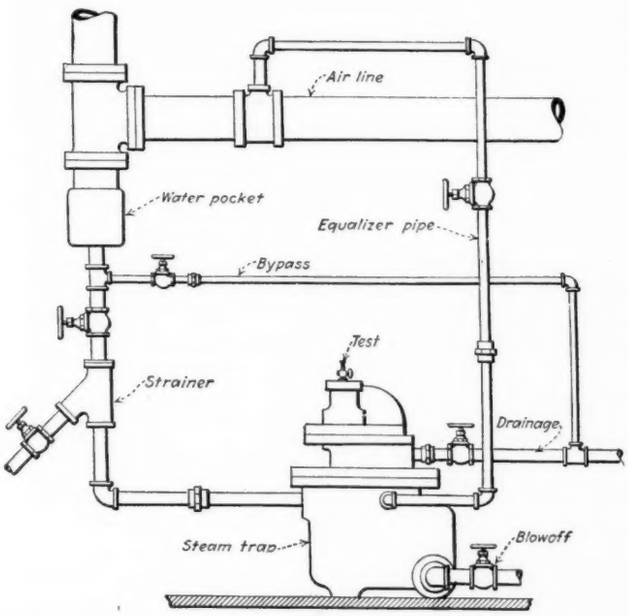


FIG. 4. USE OF TRAP TO REMOVE MOISTURE COLLECTED BY POCKET IN AIR LINE

the practice still goes on. One would not think of selecting his engine or turbine or pumps according to the size of the steam inlet pipe, but rather by the work he wishes to do or according to the horsepower it is desired to develop. So steam traps should be specified not by the size of the drip, but rather by the amount of radiation to be drained or the condensation to be handled. In short, steam traps should be specified according to the capacity required under the pressures involved and for the particular character of service being covered.

Selection and Installation

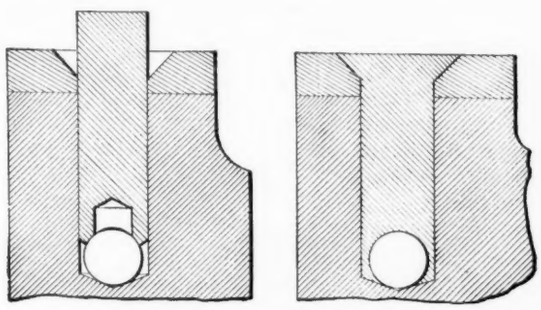
Following the item of capacity there are a few important requirements to be taken into consideration in selecting steam traps. Among the most prominent are the following: Substantial construction of all parts; simplicity of design and operation; as few parts as will achieve results; accessible working parts; generous capacity per dollar cost; ability to function properly when working at capacity; ability to function properly over a range of pressure; good steam and water joints; valves in trap so located that dirt and scale cannot settle on them; deep-water seal for valve parts; simple provision for testing or inspecting; interchangeability of parts without necessity of hand-fitting or adjustment.

As regards installations for various cases, each engineer will have to consider his own conditions. The matter of trapping is simple. As a rule it involves nothing difficult or complicated, but in unusual instances the trap expert should be consulted if the operator cannot solve the problem himself. Certain simple rules should always be borne in mind. As the water must come to the trap by gravity, the trap will naturally be placed at the low point. Pockets in the drop to the trap should always be avoided. Traps should generally be bypassed to permit removal if necessary, without holding up the process or system being drained. The bypass should be cut down to a small pipe size. This saves cost and radiation, and as a very small bypass will always handle much more condensation than the trap, the cutting of large valve discs and seats, slightly "cracked," is avoided. It is also good practice to insert a strainer in the drip ahead of every trap. This should be of the self-cleaning type so that it can be easily cleaned merely by blowing out. A few typical installations are shown in the figures of this article.

Holding a Rivet in a Blind Hole

A practical kink that might be helpful around a power plant was described by Frank C. Hudson in a recent issue of the *American Machinist*. It is meant for use in cases where a thin piece of metal is to be riveted to a larger piece that is too thick for the rivet to pass through, making it necessary to use a blind hole. The sketch shows the rivet before and after being driven home by the suggested method.

This method requires the use of a small steel ball, which is dropped into the blind hole. A hole slightly smaller than the diameter of the steel ball is then drilled into the small end of the rivet. Then, after the rivet has been cut off to the right length, driving it into the hole will first spread the lower end, causing it to bind,



USING THE TRICK WITH A STEEL BALL

and then the top may be riveted over in the usual manner. To secure the best results, according to the contributor of the idea, the proportions given in the accompanying table should be maintained.

	In.	In.	In.
Diameter of stud	3/16	1/4	5/16
Depth of hole	1/2	5/8	3/4
Size of ball	1/4	5/16	3/8
Diameter of center bore	1/16	3/32	1/8
Depth of center bore	1/32	1/32	1/32

The drawing is somewhat idealistic, in that the rivet would scarcely flow around the ball as perfectly as shown, but there is little doubt that the idea would work out satisfactorily. Frequently, it might not be convenient, in a case like this, to tap out the hole and use a stud, in which case the method described here should prove useful.

Heat Balance with House Turbine

ONE OF THE important features in the operation of a modern power plant is maintaining a heat balance, that is, having the necessary amount of exhaust steam for feed-water heating and not having any going to waste. There are a number of ways of accomplishing this, and each has its advantages under different conditions. A method that is attracting considerable interest at this time is one employing what is known as a house turbine. A diagrammatic layout for such a system is shown, in Fig. 2, on the opposite page. Steam from the boilers passes through the main turbine and is condensed in a surface condenser. Where an evaporator is used to obtain make-up feed water, the condensate is pumped through the evaporator condenser, as in the figure, and then to the condensate head tank. The make-up feed water from the evaporator may be pumped to a storage tank and allowed to flow from there to the condensate head tank as required.

Part of the steam from the boilers is utilized in a smaller turbine known as a house turbine, used to drive a generator that supplies power for the electrically driven auxiliaries. The exhaust steam from this turbine goes to a barometric condenser, where it is condensed by water from the head tank and flows to a foot tank on the condenser, the feed water being pumped from this tank back to the boiler. Where make-up feed water is supplied from an evaporator, such auxiliaries as boiler-feed pumps and forced draft fans are driven by steam and their exhaust taken to the evaporator, as in the figure. If there is an excess of exhaust above that required in the evaporator, and the pressure in the auxiliary exhaust line increases to a given value, relief valve *A* opens and the excess goes to the barometric condenser, where it is condensed, and comes back to the feed-water tank.

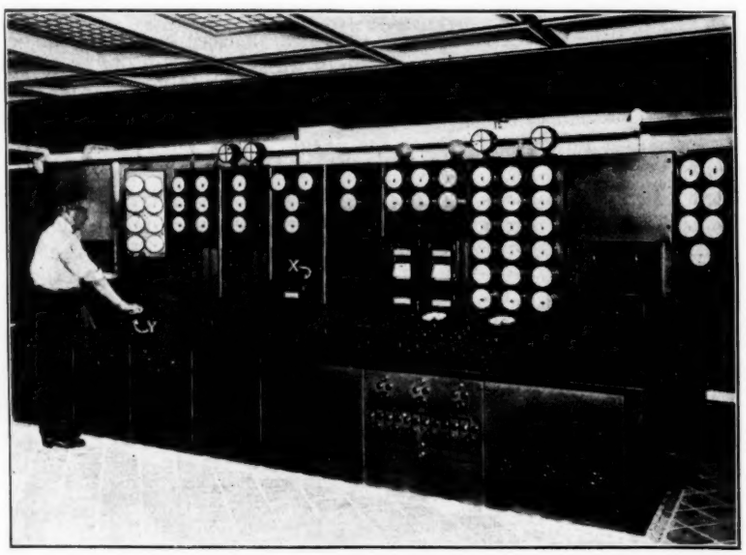


FIG. 1. FEED-WATER TEMPERATURE IS RECORDED ON THERMOMETER *X*, AND CONTROLLED BY THE OPERATOR THROUGH SWITCH *Y*, WHICH CONTROLS THE LOAD ON THE HOUSE TURBINE

To provide some flexible means whereby the amount of exhaust steam from the house turbine can be varied, so that only sufficient will be available at all times for feed-water heating, a motor-generator set is used and connected between the main and auxiliary busbars. The motor-generator set consists of an alternating-current generator connected to the house-turbine busbars, and a wound-rotor induction motor connected to the main bus, as in the figure. Sufficient resistance is connected in the motor's rotor circuit so that when it is loaded it will run about 5 per cent slower than at no load; therefore the generator on this set is designed for 57 cycles the main system 60 cycles. Likewise, the house-turbine generator is designed for 57 cycles.

In the feed-water tank is a thermometer coil, which registers the temperature of the feed-water on a graphic instrument, *X*, on the switchboard in the operating room, Fig. 1, so that the operator may make proper adjustments of the load on the house turbine to maintain the feed-water temperature at the correct value. Adjustments are made by changing the governor setting on the house turbine to make it take more or less load, as the case may be. This is done from a control switch, *Y*, on the switchboard, Fig. 1, which operates a small motor connected to the governor mechanism.

Consider a case where only the motor-generator set is supplying power to the auxiliary load, and that this loads the generator up to its full normal capacity. Under such a condition the motor would be running about 5 per cent below no-load speed and the generator would be supplying 57-cycle power. Now, if the house turbine's alternator is paralleled with the motor-generator it will go on the system at 57 cycles and will take no load. After the two generators are paralleled, the operator adjusts the governor to increase the speed of the turbine to a point where it will take load to give the necessary exhaust steam to heat the feed water, assume to where the generator is operating at 58 cycles. Under this condition the house turbine is taking, say, one-third of the load and the motor-generator set, which is also operating at 58 cycles, is taking two-thirds, its speed having increased with that of the turbine. If this does not give sufficient steam to heat the feed water the governor on the turbine is further adjusted to increase the speed, for example, to 59 cycles.

This procedure results in taking more load from the motor-generator set and transferring it to the turbine, and increasing the supply of exhaust steam. When the turbine is adjusted to the point where its generator is operating at 60 cycles, then it is carrying all the load, and the motor-generator set, which is also operating at 60 cycles, is running without any load. When there is an excess of exhaust steam for feed-water heating the operator reduces the speed of the house turbine, and the motor-generator set takes an increased share of the auxiliary-power load, thus reducing the quantity of exhaust going to the barometric heater.

By using a motor-generator set as a connecting link between the house turbine and main units any trouble on the main system is prevented from being transferred to the auxiliary system.

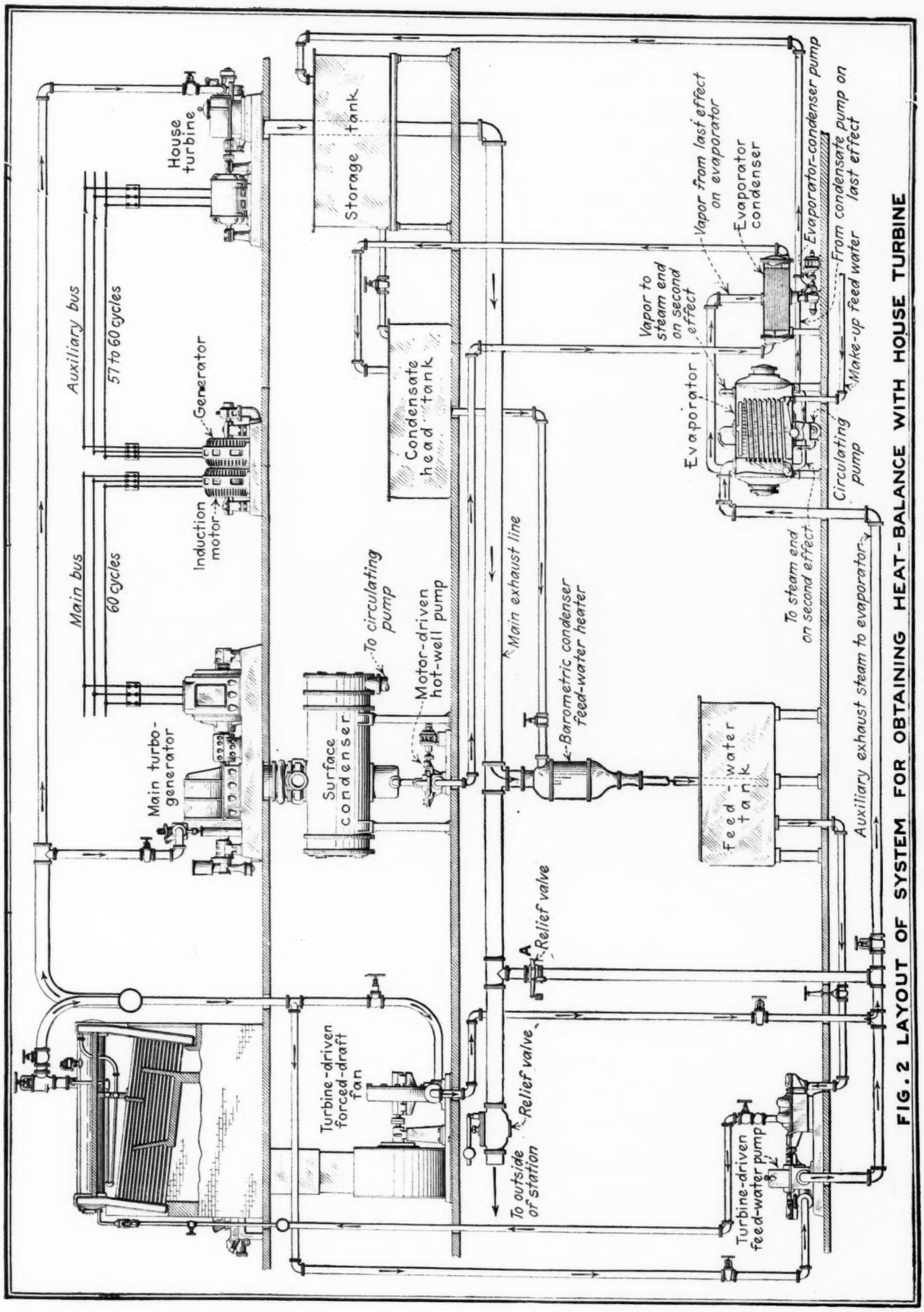


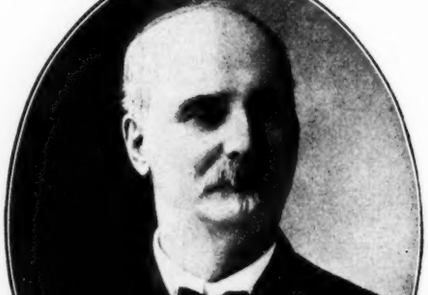
FIG. 2 LAYOUT OF SYSTEM FOR OBTAINING HEAT-BALANCE WITH HOUSE TURBINE

James G. Beckerleg

A Veteran Engineer Who Has Seen Many Conventions

A MAN is known by the company he keeps and by the opinion the "company" holds of him. Most of James Beckerleg's friends are brother engineers, members of the N.A.S.E., and he is known to them, not as James, but as "Dad" Beckerleg, a name that is often heard in power plants throughout the country. He was one of the organizers of the National Association of Stationary Engineers in 1882, and during the thirty-nine years of the association's existence, his activities and enthusiasm for it have continued with unabating zeal. Since the first meeting he has not missed a single national convention. In the functions of the Illinois State Association his services are similarly sought, and in his home local, No. 1, of Chicago, the fraternal ties are even more closely knit.

Mr. Beckerleg has had a long and interesting experience, beginning in his early days on the sea, then on the railroad and finally as a stationary engineer. He was born on May 7, 1833, in the little town of St. Ives, in Cornwall, England. Not long after his birth his father moved to London to take up employment with a shipping firm on the East India docks. When Jim was seven years old his father died; the mother, leaving a family of five, followed three years later. In these days of sorrow, Jim, at the age of ten, entered his uncle's bakery and helped to support the orphan group.



JAMES G. BECKERLEG

Jim always had a desire to go to sea, and within two years his wishes were fulfilled. His first voyage was to Lisbon in a little vessel engaged in the fruit trade and his second in a larger boat plying between Spain and England. At the age of fourteen he took service on a boat bound for Naples, and though he little realized it at the time, this trip proved to be the turning point of his life. When the ship arrived in Naples, a squadron of American warships under Commodore Morgan was lying in the bay. A sight of the stars and stripes awoke in the boy such a strong desire to visit the United States that he allowed his ship and captain to desert him on a foreign shore. Then, cap in hand, he told his story to the American commodore, who was so taken with the little English lad that he found a place for him in the "maintop squad" on the steam frigate "Mississippi." He was soon transferred to the crew of the captain's gig and in this position had an excellent opportunity to see the various cities of the Mediterranean, which the squadron visited during the following year.

Continuing with his ship, Jim landed in New York in 1849, when he was nearly seventeen years of age, received his discharge papers and went to work in Reader's boiler shop. Some months later he obtained employment with the Baltimore & Ohio R.R. in shop No. 1 in Baltimore. Later, he was transferred to the Camden Street station, where his special duties were to keep in repair the three engines running to Washington. Eventually, he was given an opportunity to try his hand at firing and in due time secured a regular appointment under Tom Beckett, a model engineer. Three years under this able instructor qualified Jim to receive an appointment as engineer on a big Newcastle engine with six-foot drivers. He was then twenty-three years of age and received three dollars a day.

For two years he remained at the throttle, and then, induced by a favorable offer from Government contractors, Hayward, Bartlett & Co., he went to Washington to install steam apparatus in the Government Treasury Building. A year later he was transferred to Chicago to work on the new Post Office Building, the date of his arrival being May 16, 1860. During the summer he was sent temporarily to work on the Government Building at Indianapolis and soon after received a permanent appointment as chief engineer of the Chicago Post Office.

Six years later, in October, 1866, he resigned this position to engage with Crane Brothers, then a small but aspiring firm, and in January, 1867, he became chief engineer for Leopold Brothers & Co., wholesale clothing merchants, with whom he remained until the firm went out of business in 1905, a period of 38 years.

During later years his active participation in N. A. S. E. affairs gained for him a wide acquaintance, so that when his old firm retired from business, it was not long before he made connections with the Dearborn Chemical Co. as salesman. Up to 1918 he remained active in this service, always attending conventions as before. Advancing age brought about his retirement under pension, but his friends are glad to see him still active in association work. This year he will again be a delegate from No. 1 and, as has always been the custom, will install the national officers at Evansville.

Jim was chief of the Chicago Brotherhood of Stationary Engineers, which was formed to help organize the N.A.S.E. and eventually became No. 1. In 1882 he was sent to New York as a delegate to the first N. A. S. E. convention, at which the by-laws and constitution were formulated and adopted and the first national officers elected. He was made treasurer, and at the second annual convention in Chicago in 1883 became president. Next year at Baltimore his re-election gave him the distinction of being the only man who has been twice so honored. For many years following he was national deputy, holding a roving commission to organize associations in all parts of the country. His enthusiasm for the cause was unlimited and, as a result of his untiring efforts, he has the credit of organizing and instituting more local associations than any other member.

EDITORIALS

How Shall Stored Coal Be Handled?

THE weekly reports of coal mined show that coal is not being stored to any extent, notwithstanding the fact that considerable publicity is being given to the wisdom and advisability of putting in storage. Many consumers have little need for coal now—their plants are not working; many have little money to invest in coal had they need for it; many more are waiting for lower coal and freight prices, overlooking the fact that coal can be bought at the mine today at a low figure.

Joint or co-operative coal purchase, recommended recently by D. L. Wing, in *Power*, has been advocated before. It is well understood that the coal pile offers the remedy for most of the ills of the coal-mining industry as well as for many of the difficulties of the railroads. It serves the same purpose as does the flywheel to the engine and the cold-storage warehouse to the food supply. Yet there appears to be no great increase in the number of consumers storing coal on a large scale, notwithstanding the lessons taught by the war.

Joint coal storage, meaning storage by many consumers co-operating as a unit, has and is being practiced in isolated instances. The most difficult task in launching such a project is to overcome inertia. To make storage worth while, there must be a real price concession on coal bought in the summer months as compared with that bought in the six months comprising the winter season. When the total cost of coal, after being put into and taken out of storage, is less than the winter cost, the consumer possessing a coal pile feels that he has shown keen business acumen. Otherwise, he must charge his loss to insurance of supply, assurance against unforeseen emergencies and precaution against possible shutdown of his plant. It may be an investment, but the average coal users consider it as an expenditure.

The railroads have opposed reduced coal freight rates during the summer as a general thing, notwithstanding Senator Frelinghuysen's efforts and the fact, as some believe, that the Interstate Commerce Commission could order reduced rates on coal. Coal operators, likewise during normal times, oppose lower prices during the summer. These facts hinder the wider adoption of the coal pile. Another fact hampering the more popular use of storage is that coal-handling costs are not known with any degree of accuracy. This cost determines whether storage is feasible or not for the individual consumer.

What does it cost to store coal and reclaim it from storage under different conditions? What investment is required for the different conditions, for the different types of coal-handling apparatus and for coal piles ranging from say, a few hundred tons up to one million and more? What is the type of apparatus best suited to the different conditions?

There are a number of methods of storing and reclaiming coal from storage, each perhaps best suited to a particular condition or set of conditions, although the field may overlap to a considerable extent. For example, the gantry crane permits of higher coal piles than where the locomotive crane is used, although the field for each overlaps in many cases. The power drag-line calls for low investment, it can be used where space is cramped, and it can reach where other types of apparatus cannot, but does it not tend to break up fragile coals? There is the monorail as a competitor of the drag-line and the portable conveyor; and the stacker, the car tipple, skip hoists of different types, etc.

Some of the factors involved in making a choice are total tonnage of pile, area covered and height of pile; grade of coal, size and friability; from what and into what the coal is moved and the distance between the two; tonnage to be handled per hour, a matter of extreme importance where rapid work is imperative, as at the northern lake ports; investment and cost per ton.

In many cases low initial investment is more important than low cost per ton, as where money is difficult to obtain, where the time is short for storing and higher economy cannot offset the higher investment. Data as to the minimum time for loading and unloading with each type of apparatus are important; also the investment expressed as a total and on the basis of tons stored.

The coming winter may, once again, compel the nation to appr e that coal should be stored in summer for winter use. An authentic statement as to handling costs is one of the first necessities in making the coal pile more general. Lower freight rates and seasonal prices may come in natural sequence in course of time.

Records that Pay

THERE is a golden mean in all things, but few find it. History shows that the majority follows the beaten paths until someone starts spreading a new gospel. Some seize upon the new idea and carry its application to such enthusiastic extremes that they over-reach; others will have nothing to do with it because it is new; natural conservatism makes them cling to the old. A few study the innovation with open minds, deciding what is valuable and what is merely freakish. Then they avail themselves of all that proves true and useful, casting the rest aside.

Such a state of affairs exists today with regard to the keeping of records of power-plant operation. Many engineers seem to feel that their life's work is being properly performed so long as they keep "juice" on the line or keep the wheels of the mill turning. What care they for a "few" tons of coal more or less? So long as the fireman keeps up steam and doesn't let the boilers explode, what else matters in the boiler room; and what else matters in the engine room so long as the wheels spin merrily around?

Another group—a small minority—has been too thoroughly inoculated with the record-keeping germ and the cost-finding microbe. Their main business in life is to cover large sheets of paper with neat little black marks that will preserve for astonished posterity the race, color, pulse and previous condition of servitude of everything, big or little, about the plant. They are so busy figuring the daily consumption of salt and pepper that they haven't time to take steps to reduce the next month's meat bill. All this is an exaggerated and possibly somewhat unfair characterization of those who worship the records for their own sakes.

The wise ones—their number is increasing daily—are willing to learn what records can do for a power plant. If there is any way of reducing the total cost of power—including fuel, labor, supplies and overhead—they want to know about it. They see at once that records of the controlling items, such as coal, steam flow and power produced, are essential, because without them they cannot tell whether the boiler room and the engine room are operating efficiently. It is also evident to them that if the over-all records indicate poor results, they will need certain intermediate records to find where the trouble lies. They will want these intermediate records taken at the points where the big leaks are liable to occur. Where there is chance for a daily variation and where the human element is important, they will want frequent or even continuous records.

When new equipment or apparatus for improving efficiency is being considered, the decision as to its purchase should depend upon the net saving obtainable. If it is known that the purchase will result in a gross saving substantially greater than the interest and depreciation on the necessary investment in addition to the yearly cost of operating the equipment, it is considered wise to make the change or addition. The value of records should be decided on the same basis.

A sensible engineer will not keep records where there is no chance for improvement. Neither will he keep them where the cost of so doing exceeds the probable saving from improved operation. On the other hand, he will not hesitate to install suitable measuring apparatus and spend a little time and money in keeping records where experience shows that the saving obtainable is considerably more than the overhead charge on the investment plus the total cost of keeping the necessary records. On this basis he will arrive at the golden mean of record-keeping and avoid being either a mossback or a faddist.

Foolproof High-Tension Switching Apparatus?

THE high-tension switching of the Dalmarnock central station, the latest addition to the power supply of the City of Glasgow, Scotland, is in every respect an innovation. To the American engineer, accustomed as he is to the massive brick or concrete work that fills the electrical galleries of our central stations, the arrangement of high-tension switching pictured on page 392 of this issue will look more like some sort of engine room than a bona fide switchhouse. Yet if the principle of the design is sound and the plans correctly established, if the workmanship and the work of assembly can be relied upon, this switchhouse should prove as safe as a public playground. All live parts are completely inclosed in metal casings or pipes and immersed in insulating compound. The tanks cannot be opened without automatically killing all current-carrying parts.

"Iron-clad" switching apparatus has been in use for some time, but this is the first instance of its application to large power-station work and relatively high voltage. Time and experience will show whether this apparatus is reliable and if the conditions necessary to make it so can always be obtained in practice. The burden of proof lies on the other side of the water at this time. Though this switching may be perfectly foolproof when perfectly put together, it is hard to see how complete destruction can be avoided if anything goes wrong. Those who are familiar with the care that must be exercised in making up the potheads on a high-tension cable system, in order to be certain that the compound will completely fill the casting and impregnate the cable insulation, will probably be dubious as to the possibility of completely filling such complicated forms. Furthermore, any insulation test on the apparatus before it is placed in service will give little assurance of future security, for a satisfactory average resistance to ground may mean a high resistance all over except in one small point, where the resistance may be too low.

The manufacturers and designers of this apparatus deserve all due credit for the ingenious design, and the engineers of the Glasgow company for the courage they show in this experiment.

Fighting Condenser Scale

A SUBSTANTIAL gain is to be credited to W. W. Jourdin and N. G. Hardy, in the fight against scale formation in surface condensers used in connection with cooling towers or spray ponds. In the editorial columns of the issue of July 5, we discussed a process consisting of the continuous treatment of the cooling-water makeup with hydrochloric acid and bemoaned the prohibitive cost of this simple solution to our troubles.

A letter from Mr. Hardy on page 390 of this issue bids us hope once more, and tells of an attempt to treat the cooling-water makeup with sulphuric instead of hydrochloric acid. This process has been in use for two months in the plant of the Arizona Copper Company, Limited, at Clifton, Arizona, and is apparently a complete success.

Several advantages are claimed for this solution over the continuous hydrochloric-acid treatment. Sulphuric acid is much cheaper than hydrochloric, and it is believed that the cost of the process will not exceed two hundred dollars a month for an average load of four thousand kilowatts, or sixty cent per kilowatt-year. Furthermore, calcium and magnesium sulphates are less likely to corrode the condenser tubes than chlorides. Although considerably less soluble than the latter, they are sufficiently so to remain in solution at concentrations usually encountered in cooling-tower or spray-pond systems, and they are claimed to be chemically stable at condenser temperatures.

Whether these claims are well founded experience will soon show. If the results prove as fair as their promises, the process should rapidly gain favor.

Of late years the design of refrigerating plants has become fairly standardized so that it is now possible with the refrigerating plant as with the steam-turbine plant, to show a typical design. The insert in *Power* this week is a cross-section of a plant including the more important items found in a modern installation.

CORRESPONDENCE

Fiber and Some of Its Uses

In reading the interesting article, "Fiber and Some of Its Uses," page 60, *Power*, July 12, it occurred to me that, perhaps without deprecating this most useful material, I might suggest the use of some caution in the indiscriminate application of fiber as an insulator.

In my experience fiber has proved rather disappointing, becoming a fair conductor at relatively low voltages, due primarily to the absorption of moisture from the air. No data, however, are submitted, since it is a matter so largely dependent upon conditions.

I have also experienced some mechanical trouble, in that small parts, such as knobs, made from fiber rod, would split very easily, along cleavage lines in the rod. Red fiber seems to be worse than gray in this respect.

Evanston, Ill. R. B. DELVIN.

Concentration of Water in Steam Boilers

I was greatly interested in the article by Victor J. Azbe, on "Concentration of Water in Steam Boilers," which appeared in *Power* on July 12. I agree with the author that controlling the blow-down of boilers by analyzing boiler water is far preferable to the haphazard method employed generally by boiler-room operators, but unless the analytical data obtained represent the true condition of the water, the results are without value.

I seriously question if the method of determining the soluble salts from the chlorine content by the method suggested by Mr. Azbe—namely, comparing the sodium chloride with a standard ratio of the solids in solution established by a chemist—will be reliable under all conditions or in fact may not even give results that are very misleading. Where the composition of the raw water makeup is constant, as would be expected from a deep-well supply, the method might be satisfactory, but with surface-water supplies subject to great fluctuations in chemical composition, the results obtained by the method suggested would not be reliable.

The chemical constituents of the boiler water used in the power plants that are under my supervision fluctuate so greatly that, by the method suggested, a ratio between the chlorine and the soluble solids could not be determined which would even approximate true conditions. The raw-water supply is obtained from surface streams subject to great changes in chemical composition, frequently within short periods.

Prior to use in the boilers our water is settled in a primary reservoir and coagulated by alum and caustic soda and then filtered through rapid sand filters. During flood periods of the river the chloride content of the supply is greatly reduced while the soluble salts are increased, either due to washing from certain portions of the watershed or to the alum and soda used at the filtration plant. At other times the chlorine may be greatly increased without a proportional increase in the soluble salts in the boiler. Circulating water used in the surface condensers is obtained from the Baltimore harbor. This water contains great amounts of chlorine as it is quite brackish. A leaky tube may greatly increase the chlorine in the boilers, while there will not be a proportional increase in solids in solution, which would take place under normal operation.

In place of the method suggested by Mr. Azbe, it would be preferable to determine the soluble solids by filtering the water through filter paper or a stone filter and evaporating the sample to dryness, then weighing the residue. It is true that this procedure requires more time and greater skill, but the accuracy of the results obtained will fully warrant the undertaking. The author of the paper in question has suggested determining the alkalinity and chlorine on the same sample of water. This is a questionable procedure, especially when it is unnecessary. To secure greater accuracy these determinations should be made on separate samples of the water. The Densimeter is unique and with careful manipulation should prove valuable.

Baltimore, Md. A. L. PENNIMAN.

Removing Oil from an Oil-Soaked Belt

As Duane Trow invites discussion in his article, "Removing Oil from an Oil-Soaked Belt," page 231 of the issue of Aug. 9, I offer the following as an explanation why the oil keeps coming to the surface of the belt:

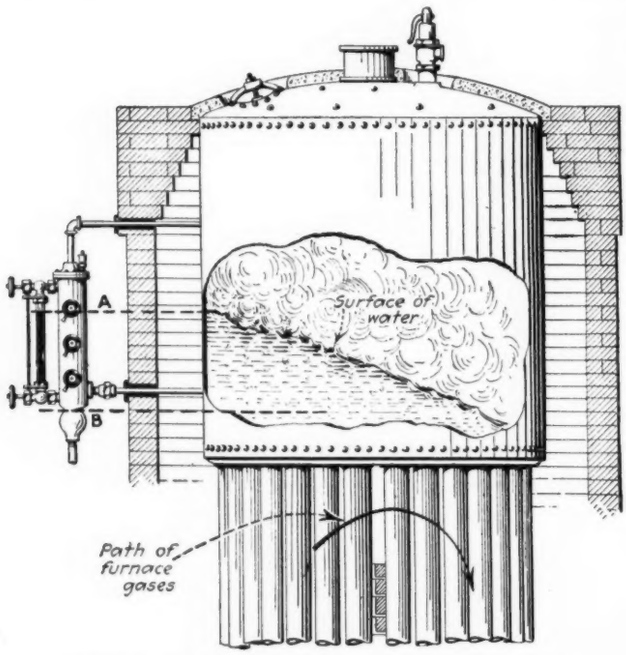
I should say that there were two forces acting in addition to capillary attraction as suggested. One, probably the greater, is centrifugal force acting on the oil as the belt travels over the flywheel and pulley. This would naturally tend to force the oil to the outer surface of the belt. The other force is that due to the internal stresses in the belt. As the belt passes over the flywheel and pulley, the surface next to the pulley is compressed, the oil being squeezed out, while at the same time the outer surface and, of course, the fibers of the belt for a short distance under this surface are being stretched. This tends to draw any oil from the inner surface.

HENRY J. E. REID.

Hampton, Va.

Hand Regulation of Feed Water

The steam-generating equipment of a certain industrial plant comprises two vertical water-tube boilers, each containing 2,500 sq.ft. of steam-making surface. The load on these boilers is unsteady, owing to an irregular demand for live steam in the several different processes that the product of the establishment requires. The demands from these departments are not always simultaneous. At certain times the boilers may be delivering the maximum quantity of steam required, and at other times one or more, or perhaps all, of the processes may be temporarily suspended. Hence the rate of evaporation in the boilers is variable.



BANKED WATER CAUSES HIGH WATER LEVEL IN GAGE GLASS

In the type of boiler used, this variation in the rate of evaporation is attended by an excessive fluctuation of the water level, and for this reason it has been found necessary to rely entirely upon hand manipulation for regulation of the feed-water supply.

When the boilers are filling the maximum demand for steam, at which times they are loaded about 50 per cent above their nominal capacity, the automatically regulated dampers are wide open, the fires are burning intensely, and the water in the nests of tubes exposed directly to the furnace gases in the first pass of the setting is evaporated at a rapid rate. The violent ebullition of the water, due to excessive crowding of the steam bubbles while escaping from the liberating surface in the front half of the steam drum and the relative lightness of the column of water on that side, causes the water to bank up as indicated in the drawing, which shows the water standing at *A* at about two-thirds the height of the gage glass. When the demand for steam suddenly drops off and the dampers close automatically, the water subsides to the level *B*, disappearing from the glass altogether.

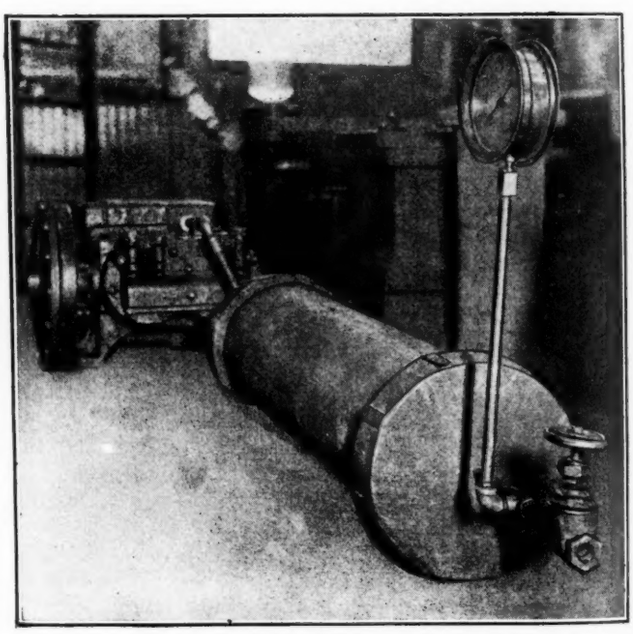
With a system of automatic feed-water regulation on these boilers the difficulty would be this: Assuming that the regulation was adjusted to maintain a water level at about midheight of the gage glass, it would open the feed valve to its full capacity when the water dropped out of sight and would hold it open until the water was restored to the normal stage in the glass. Then, in the event of a resumption of the maximum demand for steam, with the attendant increase in the intensity of the fire and, therefore, of the evaporation in the nest of tubes in the first pass, the water in the front half of the steam drum would again mount up until it would stand several inches above the top of the glass. In this case the danger of heavy priming would be imminent.

With hand regulation of the feeding apparatus the fireman simply pumps up the boilers whenever the water recedes to the level *B*, until the water stands in the glass at a height of about two inches. Then, when the maximum load again comes on, there will be little chance of the water climbing out of sight, although it may rise almost to the top of the glass.

St. Louis, Mo. A. J. DIXON.

Testing Small Air Compressors

One method of testing small motor-driven air compressors, of which a number were used about a certain power plant, is about as follows: After the machine has been repaired in the machine shop, the discharge pipe is coupled to a drum made of 12-in. diameter extra-heavy pipe, 4 ft. 3 in. long and capped at both ends. The connection between the compressor and the drum is made to one of the capped ends. The other cap is fitted with a short 1-in. pipe and tee, to the side outlet of which a connection is made for a pressure gage. The outlet end of the tee is fitted with a globe valve.



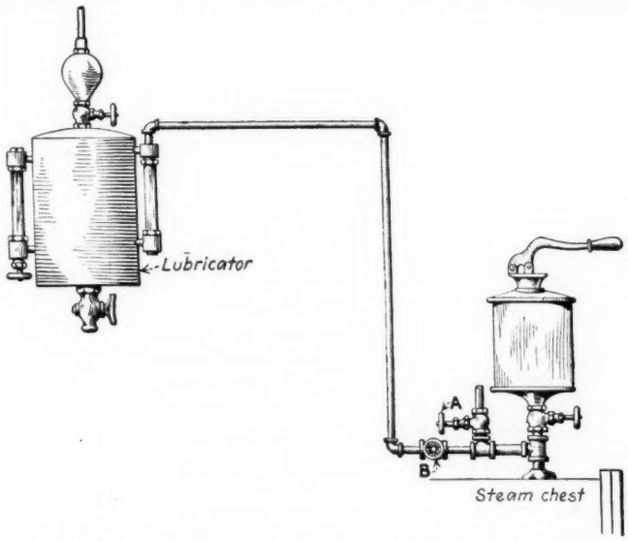
AIR TANK FOR TESTING AIR COMPRESSORS

When ready for the test the compressor is started and the pressure run up in the drum to 100 lb. The valve is for relieving the drum of pressure. With all connections tight and the valve closed, if the pressure holds at 100 it shows that the discharge valves of the compressor are tight. The condition of the piston is shown by the time necessary to pump up the pressure.

Pittsburgh, Pa. W. A. GARVIN.

A Lubrication Kink

After reading of W. R. Weiss' lubrication kink in the April 19 issue of *Power*, page 638, I suggest that he could go a little farther and save the trouble of bothering his lubricator at all, by piping the oil in at the top of the gage glass instead of at the bottom of the lubricator, and put the valve *B* close to the hand pump, and leave the drain cock in its original position



ANOTHER METHOD OF PIPING OIL TO LUBRICATOR

at the bottom of the lubricator. Then, when he filled the lubricator, it would only be necessary to close the valve *A*, open the valve *B* and pump oil into the lubricator until it is full. The water of condensation in the lubricator will be forced up through the condenser and pipe into the steam line. This small amount of water will not interfere with the operation of the engine. The feed valve need not be even closed.

I have in operation a one-pint hydrostatic lubricator that has been in service nearly ten years, and it has never had attention other than filling it. Not a new glass or a piece of packing has been put on it, neither has the sight feed been cleaned or blown out during this time, yet it is clear and gives satisfaction. It looks new and works like new. ROYCE MOSER.

Versailles, Mo.

Opening and Closing Blowoff Valves

In order to have a reserve valve in case of the failure of the main blowoff valve, the procedure recommended by Mr. Fink in *Power* of Aug. 9, is the proper one. The arrangement of valves as indicated in *Power* of June 28, in which there is a cock next the boiler and a valve outside, is in my opinion correct, as it provides a means for repairing the outer valve in case of its failure.

Almost any strongly made valve or cock will do for the inner position, although I should prefer one with a sliding contact, so as to prevent the lodgment of scale. The inner valve can be tested for tightness by opening the outer one while the inner one is closed. If this is done before washing out and leakage is indicated, it can be repaired.

For the outer valve I should prefer one of a type in which the seat is automatically cleansed while the valve is being closed, as I have found that they give more lasting service.

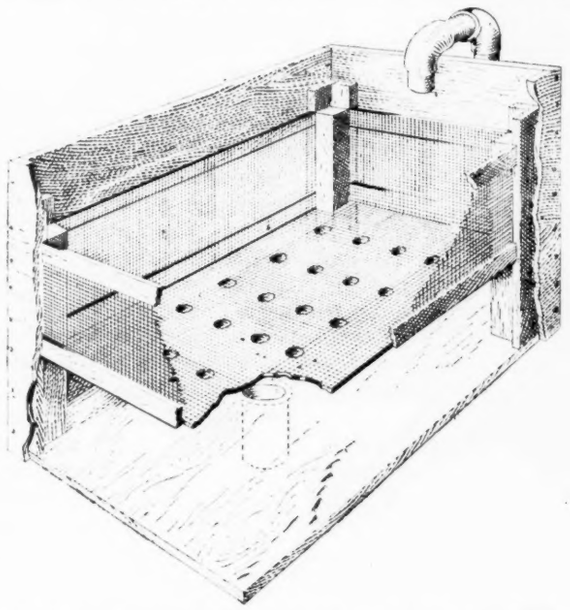
It is surprising to me that there should be any difference of opinion in regard to the order of opening and closing blowoff valves, or as to the proper time to blow down a boiler. Engineering magazines, books written by engineering authorities and, I believe, some insurance companies advise blowing down when the fires are dead, although they all admit that one, if not the principal, object in blowing down is to reduce the amount of mud in the boiler. R. MCLAREN.

Toronto, Ont., Canada.

A Home-Made Oil Strainer

Our plant is fuel-oil fired, and recently trouble was experienced with dirt in the oil clogging the burners. The oil comes to the oil pumps from two small service tanks. To insure clean oil, we carefully cleaned the tanks and then installed open strainers to strain the oil as it left the cars before entering the service tanks.

These strainers were made of wood and common mosquito-screen wire, as shown in the sketch. A wooden box 2 ft. square and 18 in. deep was made and lined with tin and provided with an outlet in the bottom which led directly to the tank. The strainer proper was made of a framework supported on four legs with the bottom 4 in. from the bottom of the box to allow room for the oil to flow to the discharge. It was necessary to make the bottom of the screen solid to withstand the impact of the falling oil, but by drilling it full of holes, as indicated, it would pass considerable oil. In the drawing the near corner of the box and screen are broken away to show the details of construction, which is merely that of a skeleton box on legs.



SIDE OF STRAINER CUT AWAY TO SHOW DETAILS OF CONSTRUCTION

When the framework is completed, the screen wire is tacked around the top and bottom and the pieces nailed inside each corner to hold it firm. The top of the screen should not come as high as the top of the box, so that in case the oil flows too fast and runs over the screen, it will run around the screen and be saved.

The oil enters by the pipe shown, falling into the screen, where it runs out through the sides and bottom into the box, from which it runs into the tank. Two

of these are set side by side, and a swing joint is arranged in the pipe so that one strainer may be used while the other is being cleaned. The screen is not fastened in place, so it is easily removed and a steam jet used for cleaning. LESLIE A. GRAY.

Wichita Falls, Tex.

Influence of Irregularities in Boiler Feed

Allen F. Brewer has a letter on the influence of irregularities in boiler feed, page 234 of the Aug. 9 issue of *Power*, which I believe should be commented upon. In the second paragraph he says: "In every boiler the heating surfaces are so designed that at a certain level of the water in the drum the most efficient operation and heat transfer will occur."

The water level in the drum has not much to do with efficient operation so long as there is sufficient water and not too much water in the drum. In other words, it would have been more nearly correct if Mr. Brewer had said, "In every boiler the heating surfaces are so designed that for the best operation the water level should always be maintained between two fixed limits—the maximum and the minimum."

In Mr. Brewer's third paragraph he says: "To operate most economically and efficiently, the boiler water must be maintained at as nearly a constant level as possible. In general this level is designed for at about the center of the gage glass, or the equivalent to two gages."

Where oil is used for fuel and where the fuel is regulated in direct proportion with the load, this statement is correct. But where coal is used for fuel, it is incorrect, because a coal fire always "lags." As coal is used more commonly in power plants than fuel oil, I believe this point should be brought out.

For example, let us assume that with coal fuel there is a sudden drop in the load and it is attempted to maintain the water level exactly at the center of the water glass. The pump is slowed down. The coal fire, of course, has a good start and cannot be stopped instantly, consequently it is giving up heat as rapidly as at full load for a short period. The result is increase in pressure and possibly the blowing of the safety valve. This is a loss and is not correct practice.

The correct way to regulate the level is to continue to feed water after a drop in load so as to absorb the surplus heat in the fuel and store it in the boiler. Then, when a sudden load comes on again, there is plenty of stored-up heat to handle the situation and plenty of time in which to fire more coal and "catch up" with the increased load.

If the water level is at the middle, say, and there is a sudden increase in load, it is improper to advance the rate of feed suddenly. The best way is to raise the heat, allowing the level to drop, and then, when the fire is well under way, increase the rate of feed. In other words, allow the water level to drop when there is an increase in load and allow it to rise when there is a decrease in load.

The best way to regulate the water level, in the writer's opinion, is to do it mechanically rather than by hand. Regulators are obtainable that control the feed much more efficiently than can be done by hand. Comparative test runs have been made in which water tenders have had their hands on the feed valves all the time in order that they might do their very best in maintaining the highest efficiency. However, it was found that the human being cannot sense the internal changes within the boiler so quickly as can the mechanical devices, and as a result the latter showed higher efficiencies. And as long as it can be done so well mechanically, it is now considered better engineering practice to let the mechanical device do it and have the operator do something that cannot be done by machinery.

Newark, N. J. W. F. SCHAPHORST.

Treating Surface-Condenser Cooling Water with Sulphuric Acid

The editorial, "Fighting Scale in Surface Condensers," in the July 5 issue which comments on the writer's article, "Removing Scale from Surface-Condenser Tubes with Hydrochloric Acid," and the article, "Eliminating Scale Troubles in Closed Surface-Condenser Cooling Systems," brings up a method of modifying cooling water, which has been in use for the last two months in this plant by the treatment of makeup water with sulphuric acid. The object of this treatment is to convert the scale-forming carbonates to sulphates, which do not precipitate at condenser temperatures with reasonable concentrations.

This method of treating makeup water was suggested by W. W. Jourdin, chief engineer power plant, Inspiration Consolidated Copper Co., Miami, Ariz. The treatment is simple, consisting in feeding sulphuric acid into the makeup water at a rate that will nearly neutralize the alkalinity. The treatment is controlled by titrating samples of water from the cooling tower with standardized sulphuric-acid solution, using methyl orange as indicator.

We have been using this treatment for only two months and during the second month had a very light load, on account of shutdown of mining and ore-treating operations. It is therefore impossible at this time to give any data of value regarding performance or cost.

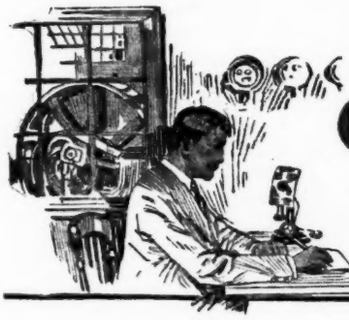
Our experience to date indicates that this treatment will almost if not entirely eliminate scale trouble. With an average load of 4,000 kw. and makeup water of which analysis was given in my previous article, the treatment cost will probably be about $200 per month, with 60-deg. Baumé sulphuric acid costing $20 to $25 per ton.

If we find in practice that the results and cost, with continuous treatment of makeup water, are as satisfactory as performance to date would indicate, this method will undoubtedly be preferable to any method of intermittent cleaning of condensers.

It is my opinion that the sulphuric-acid treatment is safer than the hydrochloric-acid treatment, as sulphates are stable and less liable to cause corrosion than chlorides. NORMAN G. HARDY.

Clifton, Ariz.

A good record is reported of a 3,200-kw. turbo-generator that was installed in the power plant of the city of Saskatoon, Canada, by the Westinghouse company in 1914. Since then the unit has been continuously available for service except for a short period in 1919, and even then it was not incapacitated by any trouble with the machine proper. The only portion of the entire equipment that was ever removed is the governor pedestal cap, which was taken off to permit of renewing the gasket on the gland runner joint. One especially long run lasted from Oct. 6, 1916, to April 22, 1917, or more than six months.



INQUIRIES OF GENERAL INTEREST

Leakage in Ammonia Compressor—How can I determine from an indicator diagram if an ammonia compressor leaks?

W. N. R.

After securing the diagram, construct an adiabatic curve through the point showing the beginning of compression. If the actual compression curve rises above the adiabatic line at any point you may be sure that the discharge valve is leaking, causing gas to flow back into the cylinder, thus increasing the pressure and volume. On the other hand, if the curve is considerably below the adiabatic, in all probability the piston allows the ammonia vapor to leak into the other end of the cylinder, which is under suction pressure. Likewise leaking suction valves will cause the same drop in the compression line, and will show by the suction elbow losing its frost. In a badly worn compressor, it is possible that one such leak will offset the other, giving a good compression line. In such cases other evidences, such as defrosting of suction line, loss of capacity and drop in discharge pressure must be considered in arriving at a decision.

Alternator's Speed Changed—The speed of a 60-cycle 2,300-volt alternating-current generator was increased from 600 to 980 r.p.m. and the voltage held at normal value by a rheostat in the field circuit. What effect would this have upon the motors connected to the circuit? The generator was speeded in our plant and the motors which were driving fans refused to work.

J. S.

When the machine was increased in speed, the frequency of the system was increased in direct proportion to the speed, or from 60 to 98. The speed of the motors would tend to increase in direct proportion to the frequency. Whether they would or not would depend upon how heavily they were loaded and the kind of load the motors were driving. If they were driving fans, their load would be increased as the cube of the speed, which in this case would mean an increase of about 300 per cent. Furthermore, the torque of the motors would vary in an inverse ratio to the increase in frequency, so that the torque would be lowered approximately 38 per cent.

The figures show that the new condition imposed upon the motors driving the fans are, a 300 per cent increase in load with a 38 per cent reduction in motor torque. It is evident that long before this condition was reached, the pull-out torque of the motors would be exceeded and they would stop.

Measuring Angle of Advance of Eccentric—How can measurement be made of the angle of advance of the eccentric of a D-slide-valve engine?

R. N. C.

With a hard pencil or a scriber make a mark on the valve stem at the end of its stuffing-box gland when the valve stem is farthest in and farthest out of the stuffing-box during a complete revolution of the engine. The distance between those marks will be the travel of the valve. Midway between the marks locate a point on the valve stem and turn the engine over to the position that will bring this middle point to the end of the stuffing-box gland. The valve stem will be at mid-travel, the eccentric will be at right angles with the center line of the engine, and the angle through which the crank would have to be turned in forward rotation to bring it to a dead center for the beginning of the stroke would be equal to the angle of advance of the eccentric.

To obtain the measurement in degrees, mark a point on the face of the flywheel to correspond with a stationary pointer brought to the wheel, turn the wheel forward until the crank comes to dead center and locate the point on the wheel which has come around to the stationary pointer. Then the distance between the points thus located on the face of the flywheel, measured in inches around the circumference, multiplied by 360 and divided by the circumference of the wheel, measured in inches at the part of the face where the points were located, will be the number of degrees of the angle of advance of the eccentric.

Or, in place of making measurements on the wheel, place the engine on a dead center, measure the distance from the position assumed by the middle mark made on the valve stem to the end of the stuffing-box when the crank is on a dead center. That distance divided by one-half of the travel will be the sine of the angle of advance, and the corresponding number of degrees can be found from a table of natural sines and cosines.

Figuring Water Power Constants—When the flow of water and working head of a water power are given and with combined waterwheel and shafting efficiency of 80 per cent, generator efficiency 94 per cent and transmission line losses 10 per cent, what are the coefficients for computing the power available, expressed in horsepower and kilowatts?

L. C.

Usually, the flow of water is expressed in cubic feet per second and the head is stated in feet. Taking the weight of a cubic foot of water as 62.3 lb., the gross energy developed per cubic foot of flow for each foot of head would be 62.3 ft.-lb. per sec., which is equal to $62.3 \div 550 = 0.1133$ hp., or $0.1133 \times 0.746 = 0.0845$ kw.

Hence, if Q = cubic feet per second and H = working head in feet, the gross power would be

$$QH \times 0.1133 \text{ hp. or } QH \times 0.0845 \text{ kw.}$$

With 80 per cent efficiency of waterwheel and mechanical transmissions, the power available at the waterwheel shaft would be

$$QH \times 0.1133 \times 0.80 = QH \times 0.09064 \text{ hp. or}$$
$$QH \times 0.0845 \times 0.80 = QH \times 0.676 \text{ kw.}$$

With 94 per cent efficiency of an electric generator, the output of the generator would be

$$QH \times 0.09064 \times 0.94 = QH \times 0.0852 \text{ hp. or}$$
$$QH \times 0.0676 \times 0.94 = QH \times 0.0635 \text{ kw.}$$

Allowing 10 per cent loss, or 90 per cent efficiency of the transmission line, the power delivered at the receiving end of the line would be

$$QH \times 0.0852 \times 0.90 = QH \times 0.0767 \text{ hp. or}$$
$$QH \times 0.0635 \times 0.90 = QH \times 0.0572 \text{ kw.}$$

[Correspondents sending us inquiries should sign their communications with full names and post office addresses. This is necessary to guarantee the good faith of the communications and for the inquiries to receive attention.—Editor.]

Dalmarnock Power Station, Glasgow, Scotland

THE new steam-electric station of the Glasgow Corporation, described in the May 27, June 10, 17 and 24 issues of *Engineering*, 1921, is located within the limits of the city of Glasgow, on the north bank of the Clyde, between that river and the Caledonian Railway. It is planned for an ultimate capacity of nearly 200,000 kw. maximum, of which 100,000 will shortly be in operation. Construction was started in 1914, but was delayed by the war, and only in September, 1920, was the first unit put in operation. Reinforced concrete was used throughout, owing to the scarcity of steel.

The generating equipment will ultimately comprise ten turbo-generators of 15,000 kw. normal, 18,750 kw. maximum continuous and 23,000 kw. maximum overload capacity. Five of these units, of three different makes, are now installed. Energy is generated at 6,500 volts three-phase cycles. Each generator is permanently tied to a bank of transformers that steps up the voltage from 6,500 volts to 20,000 volts, which is the voltage of the station buses. There is therefore no low-tension connection between the different units, thus eliminating high-current disturbances between them.

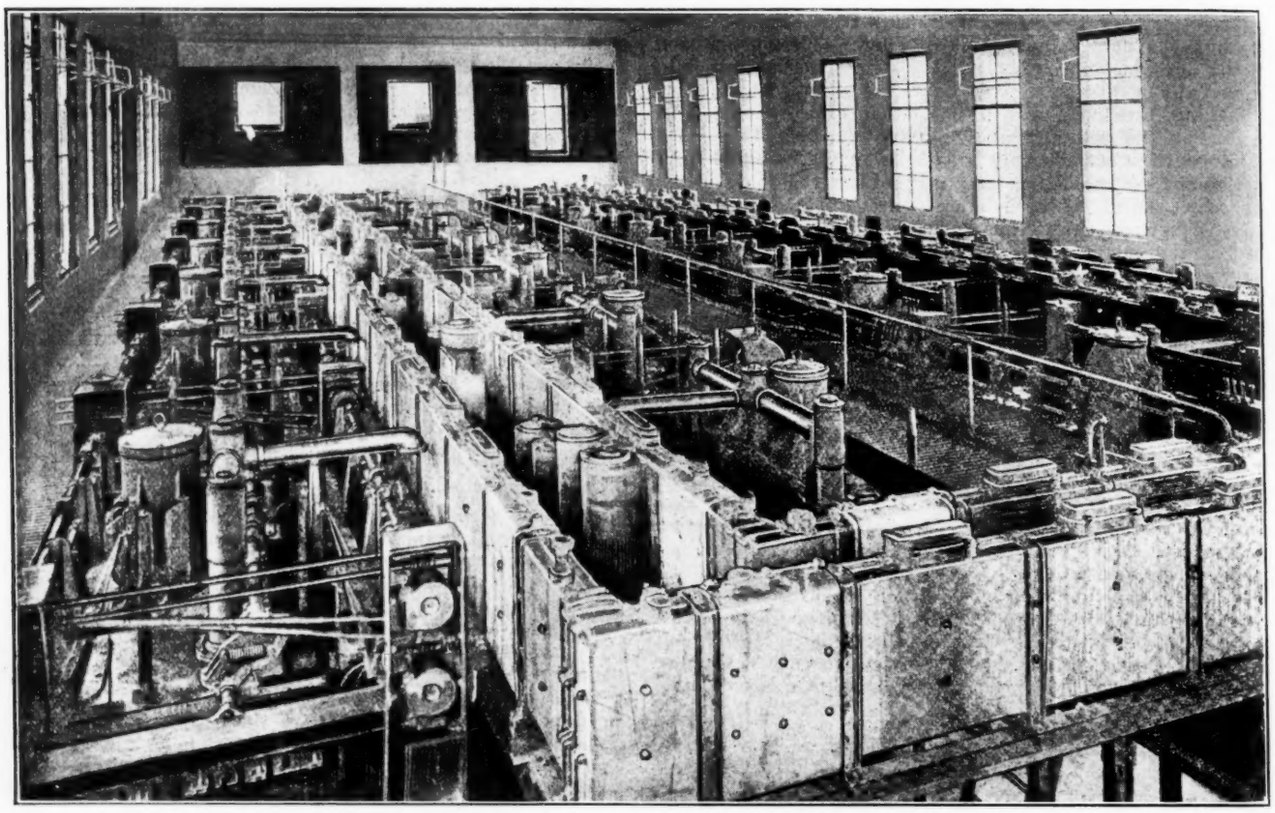


FIG. 1. VIEW OF SWITCH GALLERY

Showing the iron-clad switching equipment. All live parts including the 20,000-volt buses are inclosed in metal casings or pipes. Note the two 20,000-volt buses disposed in ring form, with oil switches inside and outside the ring, feeding onto them.

The turbines differ according to the make, two being of the simple straight-flow impulse type, two of the latest multiplé exhaust type, and one with double parallel exhaust stages. Their guaranteed steam consumption at 15,000 kw., with a vacuum of 29.1 in., is 10.2 lb. per kw.-hr. generated, and 10.32 lb. per kw. delivered to the bus; that is, including transformer losses. Each main unit exhausts into a 26,000-sq.ft. surface condenser. Four of them are further equipped with an auxiliary surface condenser, serving as a closed feed-water heater for the purpose of heat-balance control. Steam is bled from a stage of the turbine corresponding to a 19-in. vacuum and condensed in the auxiliary condenser, using the condensate from the main condenser as cooling water. The feed water leaves this heater at 155 deg. F. Two duplicate sets of boiler-feed pumps, one steam and one motor-driven, are provided for each group of four boilers, the steam-turbine unit exhausting into the hotwell. It is specified that this is to be operated only if the hotwell temperature drops below 150 deg. F.—presumably as an emergency measure in case of failure of the normal heat-balance control. All other auxiliaries are electrically driven. Those of three of the main units are supplied from the main generators either through an auxiliary 440-volt winding in the main 6,500/20,000-volt transformers, or through duplicate 1,500-kva. 20,000/440-volt three-phase station transformers. The auxiliaries of the two remaining main units are driven from a house bus fed by two 500-kva. house turbo-units. The house bus may also be supplied from the station transformers.

The provisions for heat-balance control are very complex. The exhaust from each house turbine may be turned either into the open or the closed feed-water heater on the corresponding main unit. A third open feed-water heater takes steam from the steam-ejector air extractor on the condenser of one of the main units. The feed water may therefore be heated by any combination of five different means: By the exhaust from the house turbines in the open or in the closed heaters on two of the units; or in the closed heaters of four of the units by low-pressure steam bled from the turbines; or in the open heater of the fifth unit by the steam from the air ejectors; or finally, if necessary, in the hotwell by the exhaust from the steam-driven boiler-feed pumps. The hotwell temperature is to be kept at about 155 deg. F.

The present boiler equipment consists of sixteen Bab-

cock marine-type boilers, each with 6,948 sq.ft. of heating surface and equipped with superheaters of 2,452 sq.ft. Steam is generated at a pressure of 275 lb. and at 291 deg. superheat, or 700 deg. F. total temperature. The boilers are fired under natural or forced draft, with chain-grate stokers. The normal evaporation is 50,000 lb. per hour, and it is expected to reach this figure easily without forced draft. Clyde water is used for makeup, softened and purified by the lime-soda process.

In spite of the fact that the plant is built directly on the bank of the river, no provision has been made for receiving coal otherwise than by rail. From the car-tipping mechanism, the coal is delivered either to the bunkers or to the coalyard by belt and bucket conveyors. One of the features of the plant is the coalyard, about 400 x 200 ft. and entirely inclosed by a 25-ft. reinforced-concrete retaining wall. The storage capacity is 75,000 tons, with the coal level with the top of the wall. Distribution in and from the yard is effected by means of a traveling crane-conveyor spanning 190 ft. across the yard. The ash is now being handled by means of 5-ton electric cars, though pneumatic equipment is to be installed in the future for removal of the ashes.

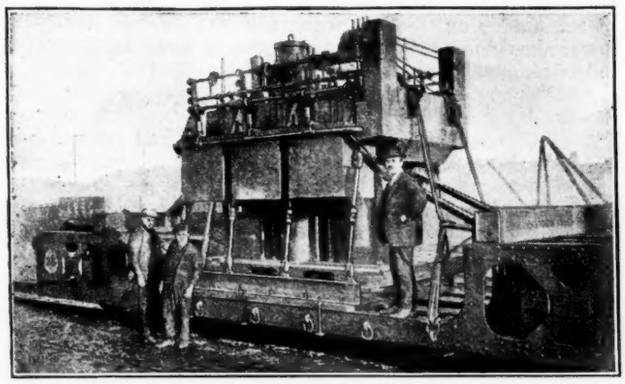


FIG. 2. IRON-CLAD OIL SWITCH BEFORE INSTALLATION

The most striking feature in the plant is the design and arrangement of the high-tension switching and buses, illustrated in Fig. 1. In the "iron-clad" switching apparatus manufactured by A. Reyrolle & Co., Ltd., all live parts are completely inclosed in cast-iron casings or piping filled with insulating compound. The 20,000-volt buses themselves are inclosed in metal casings, and no separation is afforded between the phases other than the insulation. The switch leads tapping into the bus are run in iron piping also filled with compound, and no brick or concrete barriers or compartments are to be seen in the switchhouse. Fig. 2 shows one of the oil switches on a flat car before installation.

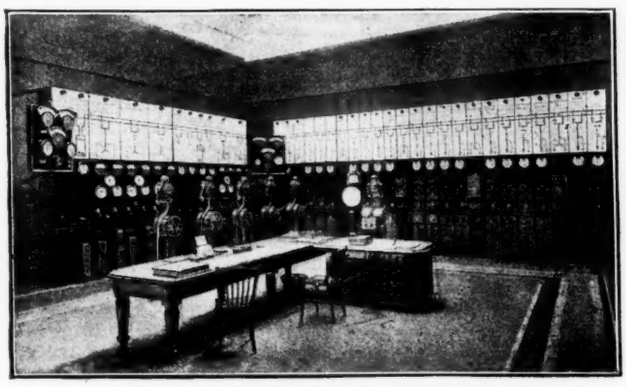


FIG. 3. VIEW OF SWITCHBOARD ROOM

Death of Peter C. Hewitt, Electrical Expert

Peter Cooper Hewitt, inventor of a number of widely known and used products and an electrical and mechanical engineer of note, died in the American Hospital in Paris on Aug. 25.

His name brings to mind instantly the so-called Cooper-Hewitt lamp, a mercury-vapor lamp whose intense green light is a familiar sight in almost all cities in this country. Another fact that links the name with every-day affairs is that it was his maternal grandfather, Peter Cooper, who gave New York City the Cooper Union for the Advancement of Art and Science, better known as Cooper Institute.

Among his electrical inventions should be mentioned the Cooper-Hewitt rectifier for transforming alternating into direct current, and an interrupter for making and breaking a circuit.

He was born in New York City in 1861 and was educated in the Stevens Institute of Technology and at the Columbia University School of Mines. From his earliest boyhood he displayed a strong interest in mechanical, chemical and electrical science. It was not until 1898, however, that he began to specialize in electrical science, and he achieved most of his success from that time on.

He was a director or trustee in a large number of companies and institutions, and was a member of a great many engineering and other associations, including the American Institute of Electrical Engineers, the American Physical Society, the Society of Naval Architects and Marine Engineers and the New York Society of Electrical Engineers.

High-Head Plant in India

Even in this country a 68,750-hp. hydro-electric plant would be notable, and so it is a matter of considerable interest that a plant of that capacity has been put up on the west coast of India by the Tata Hydro-Electric Power Supply Co.

Each of the five main Pelton-type turbines comprising the initial installation has a capacity of 13,750 hp., and there is room in the power house for three more such units. The head is approximately 1,700 ft. and the speed 300 r.p.m. The generators, which are direct-connected, are rated at 10,000 kva. and operate at 50 cycles, 6,000 volts, three-phase. There are two 720-kw. exciter sets.

On account of the climate the extremely high average air temperature of 113 deg. F. had to be allowed for in the generator design, so that the 10,000-kva. units installed would, it is estimated, be capable of delivering 16,000 kva. in a more temperate climate. In spite of this condition, however, the generators are said to have shown an efficiency of 95.8 per cent.

The long dry spells that are characteristic of the country made water storage necessary, and so three large lakes were made on the west coast at an elevation of about 1,700 ft. above sea level.

Power will be delivered at 100,000 volts over a 239-mile line to Bombay, where a large part of it will be used in cotton mills.

The tailwater will be diverted into a series of canals and used for irrigation purposes during the dry season.

The public-utility industry is out of the woods, according to a statement recently issued by Henry L. Doherty & Co., which gives the opinion of officials in the field as being that the first half of 1921 was largely a period of readjustment, and that the remaining half of the year will show decided improvement.

Blackbirds, injudiciously roosting on high-tension wires, caused a short-circuit that threw a number of places in Fulton County, N. Y., into darkness for two hours recently. The birds were electrocuted and the power company was cursed.

Washington News

New Coal Bill Introduced—Water Power Plans Being Made—Dr. Smith Returns from England

By Paul Wooton
Washington Correspondent

Just prior to the adjournment of Congress for its four weeks' recess, Representative Newton, of Minnesota, introduced a new bill (H. R. 8405) providing for Federal control of the coal industry. It is a combination of the original Calder bill and the LaFollette bill, which took the place of the Calder bill after the Senate hearings on that measure. Earlier in the session Representative Newton introduced the LaFollette bill in identically the same form in which it was reported out by the Senate Committee on Manufactures. In his present bill he picks up, with certain alterations, those sections of the original Calder bill which provide for the licensing of every operator and dealer in coal; the section empowering the Federal Trade Commission to determine when an emergency exists; the brokerage tax and the assignment of various duties to the Secretary of Labor, the Bureau of Mines, the Interstate Commerce Commission and the Geological Survey.

The brokerage tax feature of the original Calder bill carried a provision that no such taxes are to be paid by any dealer whose gross annual sales aggregate less than $500,000. Mr. Newton has changed that provision so that the tax shall not apply "to those transactions in coal in which the coal is physically handled by the seller."

Mr. Newton then departs from the text of the Calder bill to insert a section making it unlawful for any person or corporation, delinquent for more than ten days in the shipment of contract coal, to offer spot coal for sale or to deal in options on spot coal at a higher price than the price specified in the contract on which there is a delinquency.

Mr. Newton's bill was referred to the Committee on Interstate and Foreign Commerce. Under present conditions it is certain that the committee would give no consideration to any bill of this character, but it is recognized that there would be considerable demand in the House for the reporting out of some type of coal-regulation bill if there were to be a serious shortage of coal this winter. It can be stated, however, that the treatment accorded the comparatively mild Frelinghuysen bills is regarded as positive evidence that no such radical legislation as is proposed by Mr. Newton has any chance to proceed further than the Committee's pigeonhole.

Hydro-Electric Work Contemplated

According to a statement from the Power Commission, the Wisconsin-Minnesota Light and Power Co., in common with many other public utilities, has met with a steadily increasing demand for electric power and, in anticipation of a shortage, now imminent, some time ago began an investigation of possible reservoir sites to store the flood waters of Chippewa River for use during low-water periods. It has recently selected a site about 26 square miles in area, about 70 miles north of Chippewa Falls, Wis., partly within the Lac Court Oreilles Indian Reservation. After extended field investigation by the commission the company was granted a license on Aug. 8 to construct, maintain and operate a storage dam and to occupy and use Indian and public lands, which would be overflowed.

The company now depends on three plants developing 53,000 hp., located below the projected reservoir, all of which will be directly benefited by the enormous water supply impounded when the water level is raised 35 ft. by the new dam. This will be an earth-filled structure with concrete sluiceway section founded on piles and provided with three Taintor gates each 20 ft. wide and 26 ft. high.

Water will be stored between March and July each year. During the medium low-water period from August to November about 140 cu.ft. per sec. will be released, and the remainder—about 800 cu.ft. per sec.—will be used to maintain a steady flow during the winter months. By this method practically the entire flow of the Chippewa will be controlled and the company will be able to increase the primary power generated in its plants about 70 per cent.

The Stene Consolidated Copper Co. has applied for a preliminary permit to construct a rock-filled dam about 225 ft. high to be located on the Bill Williams River, about 30 miles from its mouth and approximately 45 miles from Parker, Ariz. The dam will create a reservoir about 15 miles long. A power canal 35 miles long will lead to a power house at Planet, where a head of 600 ft. will be obtained and about 28,000 hp. developed. The water from the tailrace will be used for irrigating lands in the vicinity of Parker, amounting to approximately 95,000 acres, perhaps also lands by siphoning the water across the Colorado River. Lands on the California side may be irrigated. The power developed by the project will be used for pumping and mining purposes.

Dr. Smith Tells of English Conditions

George Otis Smith, Director of the United States Geological Survey, has returned to Washington from London. The primary object of his visit to England was to serve as a member of the Organization Committee of the International Geological Congress, the next meeting of which is being arranged for August, 1922, at Brussels. Dr. Smith visited various government scientific institutions in England whose work corresponds to that of the United States Geological Survey. It is interesting to note, he remarked, that such official bureaus and commissions number not less than half a dozen, operating under nearly as many different government departments. Apparently, the logical arrangement and consolidation of such investigation work has not yet gone far in the British government.

Drawing another contrast between the two countries, Dr. Smith said: "The marked difference between England and America in the use of electricity cannot escape the notice of even the casual observer, but interviews with members of the government commissions studying this problem strengthen the opinion that industrial England suffers from a lack of machine power."

Waterpower Development in Japan

Japan is pushing work on hydro-electric development as the demand for power in the larger cities as well as the smaller villages is far in excess of the supply available, according to Stephen Q. Hayes, a special electrical engineer of the Westinghouse Electric and Manufacturing Co. Tokyo and Yokohama, near the eastern end of the main island, are supplied with power at fifty cycles from many hydro-electric plants, and there is an electrified section of the railway between these two cities with multiple-unit trains every ten or fifteen minutes.

Near the middle of the main island, about 350 miles from Yokohama and Tokyo, are the large manufacturing cities of Kyoto, Osaka and Kobe. These are fed by numerous transmission systems operating at sixty cycles. Some of the most important hydro-electric generating stations are located about halfway between the two groups of cities, and interesting problems are involved in making some of these stations suitable for feeding fifty-cycle power to Tokyo and Yokohama and sixty-cycle to Kyoto, Osaka and Kobe.

As the demand for light and power in the large cities is so greatly in excess of the available supply, rates are high and the distributing companies have not encouraged the use of electric heating appliances and household utensils. When the contemplated extensions to the power companies' systems are completed in the next few years, there will probably be a good market for electric cooking and heating appliances and labor-saving devices.

Regular monthly meetings of the operating staff of the so-called Harrison Williams properties, consisting of light and power companies in Milwaukee, Detroit, St. Louis, Youngstown and Cleveland, have been adopted to make it possible for all the plants in the system to benefit by good ideas developed in any one plant. Meetings are held in the different cities in rotation, and each meeting is devoted to a consideration of one particular subject.

Logan Plant To Be Enlarged

An extension that will cost approximately $2,000,000 is planned for the power plant of the Kentucky & West Virginia Power Co., at Logan, W. Va., and construction is already under way. The turbine room is to be considerably enlarged, and one, and perhaps two, 15,000-kva. turbines are to be installed. It is proposed also to install Taylor stokers under ten existing boilers and to make extensive improvements on the coal- and ash-handling system. In addition to this there is planned a new switchboard and a large structural steel outdoor switchyard and transformer repair house.

The Foundation Co., of Pittsburgh, has the contract for the foundations and superstructure of the buildings, and the General Electric Co. has the contract for the switchboard, turbine and outdoor switchyard equipment. The Riverside Bridge Co. is furnishing the structural steel. Plans are by F. R. Weller, consulting engineer, of Washington, D. C.; E. A. Turner is resident engineer.

In view of the large amount of work contemplated, some readers may be interested to look up an article describing the original Logan Plant, which appeared on page 818 of *Power* for Dec. 18, 1917.

Dean Anderson, New Director of Research Laboratory

Announcement has been received from the secretary of the American Society of Heating and Ventilating Engineers of the appointment of F. Paul Anderson, Dean of the College of Engineering, University of Kentucky, as director of the society's research laboratory. Dean Anderson takes the place formerly occupied by Dean John R. Allen, who died in October, 1920, a little over a year after the work had been started and just about at the time when it was being fully organized. Before his death Dean Allen had arranged that L. A. Scipio, Dean of Robert College, Constantinople, should be his assistant and associate during a leave of absence from his deanship. Thus, when Mr. Allen died, Dean Scipio took his place and continued with the work until recently, when it was necessary for him to return to his duties at Robert College. In the meantime Dean Anderson had been secured as director after a lengthy search for a man capable of performing the work.

Mr. Anderson was born Feb. 10, 1867, at South Bend, Ind. After his graduation from the South Bend High School he attended Purdue University, where he was given the degrees of B. M. E. and mechanical engineer. In 1891 he became assistant professor of mechanical engineering in the State College of Kentucky, which later became the University of Kentucky. In 1917 he was made Dean of the College of Engineering, which position he held up to the time of his recent appointment.

In his work at the college he specialized principally in steam and locomotive engineering, and was also noted as an investigator, having been the first engineer in this country to experiment with Roëntgen rays.

The merging of the San Francisco Engineering Council and the Joint Technical Society of Los Angeles into the California Federated Technical Council is now being proposed. Members of the national engineering societies to the number of 3,000, residing in San Francisco and Los Angeles, had previously formed the two associations named, and it is now suggested that they combine to secure a stronger influence over legislation.

A group of men in the Argentine Republic, being members of American national engineering societies, have formed an association that is to have its headquarters in Buenos Aires, according to the Department of Commerce.

New Publications

STATISTICAL ABSTRACT OF THE UNITED STATES FOR 1920. Prepared by the United States Bureau of Foreign and Domestic Commerce. Sold only by the Superintendent of Documents, Government Printing Office, Washington, D. C. Paper, 6 x 9 in., 874 pages. Price, 50 cents.

Statistics on almost every conceivable subject are given in this lengthy volume, frequently including data from many years back, as well as for 1920. Some of the subjects covered that are of interest to *Power* readers are as follows: Manufactures, by specified industries; patents; imports and exports; prices of coal; mineral production; steamboat inspection service; wages and hours of labor, etc.

AMERICA'S POWER RESOURCES—The Economic Significance of Coal, Oil and Water Power. By Chester Gilbert and Joseph E. Pogue. Published by The Century Co., New York City. 1921. Cloth; 5 x 7¼ in.; 325 pages, with maps and charts. Price, $2.50.

After long concentration on the practical matters immediately connected with the problem of making his living, the average good citizen either in or out of the power plant should find this book of great interest. The authors, men of high technical ability, have succeeded in making a book that is easily understood by the general public and at the same time of value to the technical man. A good idea of the contents may be obtained from the following list of chapter titles: Human Labor and Mechanical Work; The Foundation of Industrialism; Coal, the Basis of National Welfare; Oil, the Accelerator of Progress; Natural Gas, Nature's Bonus to America; Water Power, an Unused Annuity; Smokeless Fuel and Civic Progress; Power and Industrial Progress; Three-Dimensional Transportation; The Equalization of Industrial Opportunity; Co-ordination and Industrial Evolution. It is apparent from the foregoing list that the subject of fuel conservation is treated on the basis of the economic and social welfare of the country. Those who want to get a broad view of the whole fuel problem should not fail to read this book.

SELECTION OF FUELS

A series of papers on the selection and use of fuels and equipment for industrial heating operations, prepared and put in booklet form by W. S. Rockwell Co., 50 Church St., New York City. The booklet is No. 231, one of a set on industrial heating. The subject headings are: Factors governing the selection of fuels; comparative fuel prices on B.t.u. basis; comparative heating value of industrial fuel gases; composition of industrial fuel gases; the utilization of fuel resources. Much of the data given was obtained from the Bureau of Mines, and all of it should prove useful to those interested in fuel problems.

Obituary

David H. Wilson, who has been chief engineer of the Wood Worsted Mills at Lawrence, Mass., since their erection, died recently at 42 years of age. He had made Lawrence his home since he was born there in 1879. After his graduation from the grammar school he started in with the Washington Mills, where he worked under the guidance of George H. Diman, long famous as a power-plant engineer. A large delegation from the Lawrence lodge of the Elks, of which he was a member, was present at the funeral, and there was an unusually beautiful display of floral remembrances.

Robert Ten Eyck Lozier, prominent electrical consulting engineer of New York City, died recently at 53 years of age. He was born in South Norwalk, Conn., and had a business life that was varied in the extreme. His first position was with Thomas A. Edison, in which he worked on some early power plants. He was later associated with Frank Sprague, with the General Electric Co. (and with some of the earlier companies of which it was formed), with Alfred K. Warren, George Bullock, Robert Lundell, Benjamin Guggenheim, and with Dodge & Day, of Philadelphia. When the 1907 panic came, he opened a consulting office of his own, and three years later became president and general manager of Kountze Bros., bankers, interested in the development of public-utility and hydro-electric properties. Of late years he had done a good deal of consulting work for a number of prominent firms.

Society Affairs

The Association of Iron and Steel Electrical Engineers is to hold its Fifteenth annual Convention in Chicago Sept. 19-23. The Hotel LaSalle will be headquarters, and the products of 41 manufacturers will be exhibited.

The Electrical Association of Nova Scotia held its first annual meeting recently in Halifax, at which addresses were made by W. D'Arcy Ryan, of the General Electric Co.; Samuel A. Chase, of the Westinghouse Co.; E. W. Rockafellow, of the Western Electric Co.; and W. L. Goodwin, of the Society for Electrical Development.

The Nebraska Section of the National Electric Light Association is to hold its annual meeting in conjunction with a conference of the Middle West Geographic Division of the N. E. L. A. Sept. 15 and 16 at Omaha. On the evening of the first day there will be a banquet, at which President Bump and Executive Manager M. H. Aylesworth will speak.

Business Items

The S. P. Gillis Engineering and Construction Co., designer and builder of perforated radial brick chimneys, has changed its address to P. O. Box 128, Clarkdale, Arizona.

Trade Catalogs

The Warren Steam Pump Co., Warren, Mass., is distributing five new bulletins on the following subjects: "Eclipse" valve gear for single pumps; duplex outside-packed plunger pumps, end and center-packed types; duplex automatic pumps and receivers, piston and plunger patterns; vertical duplex piston pumps for boiler feed or pressure service and tank or light service; single outside-packed plunger pumps, end and center-packed types. These bulletins are numbered 106 to 110 respectively.

FUEL PRICES

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine-run bases, f.o.b. mines):

Coal	Market Quoting	Aug. 23, 1921	Aug. 30, 1921
Pool 1,	New York	$3.20	$3.00@3.50
Pocahontas,	Columbus	3.10	3.00@3.25
Clearfield,	Boston	1.75	1.50@2.10
Somerset,	Boston	1.60	1.50@1.85
Pittsburgh,	Pittsburgh	2.10	2.20@2.30
Kanawha,	Columbus	2.15	2.00@2.25
Hocking,	Columbus	2.15	2.00@2.25
Pittsburgh No. 8	Cleveland	2.30	2.25@2.35
Franklin, Ill.,	Chicago	2.80	2.25@3.50
Central, Ill.,	Chicago	2.40	2.00@2.75
Ind. 4th Vein,	Chicago	2.50	2.25@2.75
Standard,	St. Louis	1.85	1.75@1.90
West Ky.,	Louisville	2.65	2.15@2.75
Big Seam,	Birmingham	2.15	2.00@2.20
S. E. Ky.,	Louisville	2.35	2.15@2.40

New York—On Aug. 31, Port Arthur light oil, 22@25 deg. Baumé, 4¼c. per gal. 30@35 deg., 5¼c. per gal. f.o.b. Bayonne, N. J.

Chicago—Aug. 27, for 24@28 deg. Baumé, 40@45c. per bbl.; 32@34 deg. 1¼@1½c. per gal. in tank cars f.o.b. Oklahoma refinery, or freight adjusted.

Pittsburgh—On Aug. 29, f.o.b. refinery; Pennsylvania, 36@40 deg., 3¼ to 4c. Oklahoma, 24@30 deg., 45@50c. per bbl., gas oil, 32@34 deg., 1¼c. per gal., 36@38 deg., 1¼c. 38@40 deg., 1¾c.

St. Louis—Aug. 27, prices f.o.b. cars, tank lots; 24@26 deg. Baumé, 46c. per bbl.; 26@28c. deg., 55c.; 28@30 deg., 60c.; 32@34 deg. 1¼c. per gal.

Philadelphia—On Aug. 29, 26@28 deg. Baumé, Oklahoma, 50c. per bbl.; 30@34 deg., Oklahoma (group 3) 75c. per bbl.; 16@20 deg. Seaboard, 3¼c. per gal.

Cincinnati—Aug. 31, for 22@28 deg. Baumé, 3c.; Diesel, 26@30 deg., 2¼c. per gal.

Cleveland—Aug. 31, for 22@28 deg. Baumé, 5c. per gal.

New Construction

PROPOSED WORK

Mass., Boston — The Olympia Theaters, Inc., 142 Berkeley St., will soon award the contract for an 8 story, 100 x 256 ft. theater and office building on Washington St. About $1,000,000. Mowell & Rand, 50 Bromfield St., Archts.

R. I., Providence—The city, Public Bldg. Dept., plans to build a 3 story high school on Pond St. About $1,250,000. Architect not selected.

R. I., Providence—The city, Public Bldg. Dept., plans to build a 3 story grade school and auditorium. About $500,000. Architect not selected.

Conn., Hartford—The Fuller Brush Co., Inc., 74 Union Place, is having plans prepared for a 4 story, factory on Windsor Ave. About $250,000. Buck & Sheldon, Inc., 60 Prospect St., Archts. and Engrs.

Conn., Hartford—C. J. Malmfeldt, Archt., 206 Trumball St., is receiving bids for a 7 story, 50 x 160 ft. addition to hospital including a steam heating system on Hudson St. for the Hartford Hospital. About $500,000.

Conn., New Haven—C. D. Palmer, Archt., 114 Whitney Ave., is receiving bids for a 4 story, 50 x 125 ft. private ward building for the New Haven Hospital, 330 Cedar St. About $400,000.

N. Y., Brooklyn—Bd. Educ. had plans prepared constructing P. S. 187 at 65th St. and 12th Ave., about $1,000,000 and 5 story addition to P. S. 67 on North Elliott Pl., about $600,000. C. B. J. Synder, Municipal Bldg., New York City, Archt. and Engr.

N. Y., Buffalo—The Buffalo Mill Supply Co., 210 Main St., is in the market for conveying machinery for unloading salt from box car to crusher. G. J. Braun, Purch. Agt.

N. Y., Buffalo—The Danahy Packing Co., 25 Metcalfe St., having plans prepared for a 4 story, 60 x 67 ft. cooler for packing plant. About $45,000. H. Brown, 28 Glenwood Ave., Archt.

N. Y., New York—Bd. Educ., 500 Park Ave., having plans prepared by C. B. J. Snyder, Archt. and Engr., Municipal Bldg., for constructing P. S. 80, on 121st St. and 1st Ave., about $750,000; also P. S. 58 at 176th St. and Washington Ave., about $500,000.

N. Y., New York—V. Gerabone, c/o G. F. Pelham, Archt., 200 West 72d St., will soon receive bids for a 5 story, 100 x 100 ft. apartment at 316 West 89th St. About $250,000.

N. Y., New York—The Sun Printing and Publishing Co., had plans prepared for a 26 story, 56 x 57 ft., bank and office building on Nassau and Franklin Sts. About $600,000. McKim, Mead & White, 101 Park Ave., Archts.

N. J., Paterson—The Bd. Educ. will soon award the contract for school No. 2 on Mill and Passaic Sts. About $400,000. Lee & Hewitt, 25 West Bway., New York City, Archts. and Engrs.

Pa., Chester—F. F. Durang, Archt., 1220 Locust St., Phila., will receive bids until Sept. 10, building 4 story, 108 x 112 ft. hospital on 7th and Butler Sts., for St. Hames Hospital. About $250,000. Noted Aug. 16.

Pa., McKeesport—McKeesport Hospital is receiving bids for constructing power house, dormitory, nurses' home and garage on 5th Ave. About $250,000. S. F. Heckert, Bessemer Bldg., Pittsburgh, Archt. Noted May 17.

Pa., Piladelphia—The city will receive bids until Sept. 15 for the following:

Furnishing and laying electric duets from Belmont Pumps to Filters, about 7,000 ft. Contract 517.

Electric transmission cable for Belmont pumping station, about 7,00 ft. Contract 528.

Permanent installation of pumping units at Belmont pumping station and constructing new foundation and moving pumps and machinery to same. Contract 519.

General improvements to Larners Point Pumping station, additional coal handling equipment also addition to boiler houses No. 2 and 3. Contract 513.

Electric crane for Shawmut pumping station.

Alterations and additions to coal storage and handling system. Contract 520.

C. E. Davis, 792 City Hall, Ch. Water Bu.

Pa., Pittsburgh — The Union Ice Co., North Side, is receiving bids for 2 story, 70 x 163 ft. cold storage plant on Beaver Ave. Cost between $90,000 and $100,000. C. G. Gerber, Archt.

D. C., Washington—The Bd. of Comrs. is having plans prepared for the new Eastern High School. About $1,500,000. A. L. Harris, District Bldg., Municipal Archt.

D. C., Washington—The Bureau of Yards and Docks, Navy Dept., plans to make alterations and additions to the heating system in the Naval Hospital. Spec. 4510.

Va., Norfolk—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., plans to make alterations and additions to underground heating system and drainage for electrical distributing system. Spec. 4512.

Va., Yorktown—The Bureau of Yards and Docks, Navy Dept., Wash., D. C., will receive bids until Sept. 14 for mechanical equipment and distributing system. Spec. 4508.

O., Columbus—The City Bd. of Purchase and W. H. Duffy, Dir. of Service have rejected bids for a 1,000 hp. boiler for the municipal light plant. Bids will be readvertised later.

Mich., Detroit—The Bd. Water Comrs., Water Wks. Park, received bids for furnishing and installing 4 400 hp. water tube boilers in pumping station from Wickes Boiler Co., 512 North Water St., Saginaw, $36,187. Erie City Iron Wks., Erie, Pa., $35,000 (single drum boilers), and Springfield Boiler Co., 330 S. E. Grand Ave., Springfield, Ill., $36,300 (single cross drum); for furnishing and installing 4 underfeed stokers for 400 hp. water tube boilers including engines and clarage fans from the Detroit Stoker Co., 7342 Woodward Ave., $22,230. The American Engineering Co., Aramingo and Cumberland Sts., Phila., Pa., $22,995, and the Frederick Eng. Co., Frederick, Md., $22,656.

Mich., East Lansing — Pond & Pond, Archts., 64 West Van Buren St., Chicago, Ill., will soon receive bids constructing a 3 story, 145 x 175 ft. club house, for The Michigan Agricultural College, Union Bd. About $500,000. A steam heating system will be installed.

Ill., Chicago—C. H. Eckstrom, Archt., 5 North La Salle St., is receiving bids constructing an 8 story, 99 x 121 ft., printing plant, including a steam heating system at 500-10 North Dearborn St., for W. D. Boyce, 508 North Dearborn St. About $400,000.

Ill., Chicago—Holabird & Roche, Archts., 104 South Michigan Ave., will soon receive bids constructing 12 story, 120 x 192 ft. office building, including a steam heating system at 1206-24 North Michigan Ave., for The Illinois Life Insurance Co., Otis Bldg. About $500,000.

Ill., Collinsville — The City Council, J. Bailey, Clk., will receive bids until Oct. 7 for furnishing and installing 2 steam pumps and sinking 2 wells for the Municipal Waterworks System.

Wis., Barksdale — The Farm & Labor Co-op. Assn., c/o E. Huff, Pres., having plans prepared for a 2 story, 29 x 96 ft. cheese factory, etc., including a steam heating and power system on Main St. About $30,000. Private plans.

Wis., Milwaukee—The School Bd., 10th and Prairie Sts., plans to build heating plant and boiler house at the following schools:

The Twenty-first, Walker, Madison Sts., and Maryland Ave. schools. About $40,000 each.

Walnut St. school about $50,000 and the Weil St. school about $18,000.

Van Ryn & De Gelleke, 114 Grand Ave., Archts. and Engrs.

Wis., Portage—The Portage Co-operative Canning Co., Michel Bldg., plans to build a 1, 2 and 3 story cannery, including power house, etc. About $275,000. Architect not selected.

Wis., Prairie du Chien—Alvord & Burdock, Engrs., 8 South Dearborn St., Chicago, Ill., will receive bids until Sept. 13 for a waterworks pumping station, centrifugal pump, etc., for the the city, F. R. Honzel, City Clk.

Wis., Institution (Sturgeon Bay P. O.)—Consolidated Dist. plans to build 3 story, 95 x 160 ft., high and grade school including separate power house. About $150,000. Juul, Smith & Reynolds, Dempsey Bldg., Manitowoc, Archts.

Mo., St. Charles—The city is having plans prepared by Benham & Mullergren, Consult. Engrs., Firestone Bldg., Kansas City, for a municipal electric light plant and distributing system. About $200,000. O. Boekemeier, City Clk.

Mo., Clinton—The city, c/o G. Hart, City Clk., City Hall, is in the market for a steam condenser for the electric power plant. About $5,000.

Mo., Clinton—The Clinton Light & Water Co., is receiving bids for installing 3 electric pumps. About $5,000. J. Lear, Engr.

Kan., McCracken — The city plans to build a 40 x 45 ft. power house addition to the municipal plant, capacity 200 kw., 3 phase, 60 cycle, two 150 hp. oil engines and 5 panel switchboard. About $40,000. Ruckel Eng. Co., Hutchinson, Engrs.

Kan., Quinter—The city is having plans prepared for an addition to municipal power plant. About $45,000. Ruckel Eng. Co., Hutchinson, Engrs.

Ia., Des Moines—The Bd. Educ., c/o G. L. Garton, Secy., will receive bids until Sept. 27 for a 2 story, 240 x 360 ft. high school on 9th and Loomis Sts., including boiler plant. About $700,000. Proudfoot, Bird & Rawson, 810 Hubbell Bldg., Archts. Separate bids will be taken on heating and ventilating installations.

CONTRACTS AWARDED

Conn., New Haven — Bigelow Co., 92 River St., has awarded the contract constructing a 1 story, 55 x 105 ft. boiler house to H. R. Kent Co., Rutherford, N. J. About $20,000.

O., Cleveland — Cleveland Elec. Illuminating Co., Illuminating Bldg., has awarded the contract building a 1 story, 25 x 73 ft. power house addition at 12507 Plover Ave., to Hunkin-Conkey Constr. Co., Century Bldg. About $25,000.

Wis., River Falls—City c/o G. Smith, Mayor has awarded the contract constructing pump house and filter basin, pumps, etc., to J. W. Hildred Co., 1019 Commerce Bldg., St. Paul, $9,844. Noted Aug. 16.

Mont., Browning—City has awarded the contract furnishing 125 ft. steel tower with 75,000 gal. tank, drilled well, pump house and equipment, etc., to the Two Miracle Co., 437 Ford Bldg., Great Falls. About $55,000.

Okla., Tulsa—W. H. Hocster, Engr. for City, has awarded the contract for improvements to the water-works pumping station, to Tibbets & Pleasant, Inc., New Daniel Bldg., $129,000. Equipment including a 12,000,000 gal. low service pump will be installed.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

POWER-PLANT SUPPLIES

HOSE—

Fire — 50-Ft. Lengths

Underwriters' 2½-in.	56c. per ft.
Common, 2½-in.	50–5%

Air

First Grade	Second Grade
¼-in. per ft. $0.38	$0.22½

Steam—Discounts from List

First grade....40–10% Second grade...50–5% Third grade....50–10–5%

RUBBER BELTING—The following discounts from list apply to transmission rubber and duck belting:

Competition..... 60–5% Best grade..... 50–10%

LEATHER BELTING—Present discounts from list in fair quantities (½ doz rolls):

Light Grade	Medium Grade	Heavy Grade
50–5%	45%	40%

RAWHIDE LACING { For cut, best grade, 50–10%, 2nd grade, 60%.
For laces in sides, best, 41c. per sq.ft.; 2nd, 39c.
Semi-tanned: cut, 50%; sides, 43c. per sq.ft.

PACKING—Prices per pound:

Rubber and duck for low-pressure steam	$1.00
Asbestos for high-pressure steam	2.00
Duck and rubber for piston packing	1.00
Flax, regular	1.20
Flax, waterproofed	1.70
Compressed asbestos sheet	1.00
Wire insertion asbestos sheet	1.50
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.59
Rubber sheet, cloth insertion	.30
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.25
Asbestos wick, ½- and 1-lb. balls	.75

PIPE AND BOILER COVERING—Below are part of standard lists, with discounts.

PIPE COVERING		BLOCKS AND SHEETS	
Pipe Size	Standard List Per Lin.Ft.	Thickness	Price per Sq.Ft.
1-in.	$0.27	½-in.	$0.27
2-in.	.36	1-in.	.30
6-in.	.80	1½-in.	.45
4-in.	.60	2-in.	.60
3-in.	.45	2½-in.	.75
8-in.	1.10	3-in.	.90
10-in.	1.30	3½-in.	1.05
85% magnesia high pressure			33⅓% off
For low pressure heating and return lines		4-ply	50% off
		3-ply	52% off
		2-ply	54% off

PORTLAND CEMENT—New York, $2.60@2.70 without bags, in cargo lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $2.88 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York Current	Cleveland	Chicago
White	7.50@10.00	12.00	12.00
Colored mixed	5.50@ 9.00	9.00	10.00

WIPING CLOTHS—Jobbers' price per 1,000 is as follows:

	13½ x 13¼	13½ x 20½
Cleveland	$55.00	$65.00
Chicago	55.00	65.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.78	$0.83	$0.80

WHITE AND RED LEAD—Base price per pound:

	Red — Current		Red — 1 Year Ago		White — Current		White — 1 Yr. Ago	
	Dry	In Oil	Dry	In Oil	Dry and In Oil		Dry and In Oil	
100-lb. keg	12.25	13.75	15.50	17.00	12.25		15.50	
25- and 50-lb. keg	12.50	14.00	15.75	17.25	12.50		15.75	
12½-lb. keg	12.75	14.25	16.00	17.50	12.75		16.00	
1-lb. cans	15.25	16.75	18.50	20.00	15.25		18.50	
5-lb. cans	17.25	18.75	20.50	22.00	17.25		20.50	

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅞ and smaller	50–10%	60–10%	60–10%
Tinned	50–10%	60–10%	45%

Structural rivets, ¾, ⅞, 1 in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York....$4.40 Chicago....$3.68 Pittsburgh....$2.65

Boiler rivets, same sizes:

New York....$4.50 Chicago....$3.78 Pittsburgh....$2.75

REFRACTORIES—Prices in carlots:

Chrome brick, eastern shipping points	net ton	55.00@60.00
Chrome cement, 40@45% Cr_2O_3	net ton	30.00
Chrome cement, 40@45% Cr_2O_3 in sacks	net ton	33.00
Clay brick, 1st quality, fire clay, 9-in. shapes, Pennsylvania, Ohio and Kentucky	per 1,000	37.00
Clay brick, 2nd quality, fire clay, 9-in. shapes Pennsylvania, Ohio and Kentucky	per 1,000	32.00
Magnesite brick: 9-in. straight	net ton	65.00@70.00
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@76.50
Magnesite brick: Soaps and splits	net ton	91.00@96.00
Silica brick: Chicago district	per 1,000	38.00
Silica brick: Birmingham, Ala	per 1,000	34.00
Silica brick: Mt. Union, Pa	per 1,000	33.00
Magnesite cement: Eastern shipping point, in bags	net ton	
Magnesite cement: Eastern shipping point, in bags	net ton	

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
Best grade	70.00	35.50	35.00
Commercial	30.00	13.50	9.00

COLD FINISHED STEEL—Warehouse prices are as follows:

	New York	Chicago	Cleveland
Round shafting or screw stock, per 100 lb. base	$4.23	$3.85	$3.85
Flats, square and hexagons, per 100 lb. base	4.73	4.35	4.35

BOILER SPECIALTIES—F. o. b. **New York** or **Jersey City**, discounts on list:

	Current
Copper ferrules	75%
Boiler flanges	55%
Boiler stay bolts	60%
Boiler patch bolts	Net list
Boiler fitting-up bolts	50%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots on the Pittsburgh basing card of July 7, 1921:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	64½	52	1¼ to 1½	39½	24½

LAP WELD

2	56½	44	2	34½	20½
2½ to 6	60½	48	2½ to 4	37½	24½
7 to 12	57½	44	4½ to 6	37½	24½
13 and 14	45	37	7 to 12	35½	22½

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	62½	51	1 to 1½	39½	25½
2 to 3	63½	52			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	54½	43	2	35½	22½
2½ to 4	58½	47	2½ to 4	38½	26½
4½ to 6	57½	46	4½ to 6	37½	25½
7 to 8	53½	40	7 to 8	30½	18½
9 to 12	48½	35	9 to 12	25½	13½

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.22
1¼	.....	.....	.21
1½	.....	.....	.19
1¾	$0.2332	$0.2855	.24
2	.1848	.22	.20
2¼	.2112	.2514	.22
2½	.2220	.2955	.26
2¾	.2516	3349	.30
3	.2812	.3743	.33
3¼	.3330	.4320	.32
3½	.3264	.4608	.34
4	.4148	.5856	.43

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2¼ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$ 46.50(net)	$138.00	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:

Less than coil lots	20%	10%
Coils to 1,000 ft.	30%	25%
1,000 ft. and over	40%	30%

BATTERIES, DRY—Regular No. 6 size red seal, Columbia, or Ever-Ready:

	Each, Net
Less than 12	$0.40
12 to 50	.34
50 to 125 (bbl.)	.30½
125 (bbl.) or over	.29

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f. o. b. New York, with 10-day discount of 5 per cent.

	Conduit		Elbows		Couplings	
Size, In.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.	Black 2,500 to 5,000 Lbs.	Galvanized 2,500 to 5,000 Lbs.
¼	$64.43	$69.53	$15.35	$16.49	$5.85	$6.08
⅜	83.72	90.62	20.20	21.70	8.08	8.68
1	120.36	130.56	29.99	32.12	10.50	11.28
1¼	162.84	176.54	38.61	41.31	14.59	15.61
1½	194.70	211.20	51.48	55.08	18.02	19.28
2	261.96	284.16	94.38	100.98	24.02	25.70
2½	414.18	449.28	154.44	165.24	34.32	36.72
3	541.62	587.52	411.84	440.64	51.48	55.80
3½	678.96	734.16	909.48	973.08	68.64	73.40
4	826.22	891.62	1,051.05	1,124,55	85.80	91.80

CONDUIT NON-METALLIC, LOOM—

Size I. D., In.	Feet per Coil	List, Ft.
¼	250	$0.05½
½	250	.06
¾	250	.09
¾	200	.12
¾	200	.15
1	150	.18
1	100	.25
1¼	100	.33
1½	Odd lengths	.40
2	Odd lengths	.55

1000 ft. and over.... 65% Coils..... 55% Less coils, 45%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.10	D. P. D. B.	$0.38
D. P. M. L.	.18	T. P. to D. P. S. B.	.23
T. P. M. L.	.28	T. P. S. B.	.34
D. P. S. B.	.20	T. P. D. B.	.55

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.45	$1.15	$1.45
T. P. M. L.	.63	1.60	2.15
D. P. S. B.	.57	1.45	.....
T. P. S. B.	1.04	2.10	.....
D. P. D. B.	.99	2.65	.....
T. P. D. B.	1.70	4.80	.....
T. P. to D. P. D. B.	1.15	3.40	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton twisted	$12.50
No. 16 cotton twisted	15.75
No. 18 cotton parallel	14.50
No. 16 cotton parallel	18.00
No. 18 cotton reinforced heavy	20.50
No. 16 cotton reinforced heavy	24.00
No. 18 cotton reinforced light	18.75
No. 16 cotton reinforced light	22.00
No. 18 cotton Canvasite cord	15.00
No. 16 cotton Canvasite cord	17.75

FUSES, ENCLOSED—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.,	100	$0.25	3-amp. to 30-amp.,	100	$0.40
35-amp. to 60-amp.,	100	035	35-amp. to 60-amp.,	100	.60
65-amp. to 100-amp.,	50	.90	65-amp. to 100-amp.,	50	1.50
110-amp. to 200-amp.,	25	2.00	110-amp. to 200-amp.,	25	2.50
225-amp. to 400-amp.,	25	3.60	225-amp. to 400-amp.,	25	5.50
425-amp. to 600-amp.,	10	5.50	450-amp. to 600-amp.,	10	8.00

Discount: Less 1-5th standard package, 40%; 1-5th to standard package, 45%; standard package, 50%.

RENEWABLE FUSES, ENCLOSED—

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50 ea.	$1.10 ea.	100	10
35 to 60-amp.	1.00 ea.	1.25 ea.	100	10
65 to 100-amp.	2.00 ea.	3.00 ea.	50	5
110 to 200-amp.	4.00 ea.	5.00 ea.	25	5
225 to 400-amp.	7.50 ea.	11.00 ea.	25	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1
450 to 600-amp.	11.00 ea.	16.00 ea.	10	1

RENEWAL LINE FOR ABOVE FUSES—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package	$3.25
0-30 ampere, less than standard package	3.75

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs — Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs — Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.40	$0.45	100	75	$0.75	$0.80	50
15	.40	.45	100	100	1.10	1.20	24
25	.40	.45	100	150	1.55	1.65	24
40	.40	.45	100	200	2.10	2.25	24
50	.40	.45	100	300	3.15	3.35	24
60	.45	50	100				12
				500	4.60	4.85	12
				750	6.50	6.85	8
				1,000	7.50	7.85	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $150 to $300,000 net allow a discount of 17 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.24
Composition 2-piece attachment plug	.32
Swivel attachment plug	16
Current taps	40

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York.

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$ 6.00	$ 7.80	$9.00	$14.50
12	8.00	10.20	11.95	19.20
10	10.95	12.75	15.20	24.68
8	14.25	16.60	19.50	32.91
6	.....	.....	29.35	.....
4	.....	.....	39.30	.....
2	.....	.....	55.00	.....
1	.....	.....	74.32	.....
0	.....	.....	93.00	.....
00	.....	.....	111.64	.....
000	.....	.....	133.72	.....
0000	.....	.....	159.52	.....

SOCKETS, BRASS SHELL—

¼ In. or Pendant Cap — Key Each	Keyless Each	Pull Each	⅜ In. Cap — Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.50	$0.39	$0.36	$0.56

Less 1-5th standard package	+25%
1-5th to standard package	List
Standard package	20%

WIRE, ANNUNCIATOR AND DAMPPROOF OFFICE—

No. 18 B. & S. regular spools (approx. 8 lb.)	33c. lb.
No. 18 B. & S. regular 1-lb. coils	34c. lb.

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 37c. lb., 100 lb. lots	33c. lb.
Rubber tape, ¾ in., less 100 lb. 37c. lb., 100 lb. lots	32c. lb.
Wire solder, less 100 lb. 30c. lb., 100 lb. lots	23c. lb.
Soldering paste, 2 oz. cans	$1.50 doz.

SWITCHES, KNIFE—

TYPE "C" NOT FUSIBLE

Size, Amp.	Single Pole, Each	Double Pole, Each	Three Pole, Each	Four Pole, Each
30	$0.42	$0.68	$1.02	$1.36
60	.74	1.22	1.84	2.44
100	1.50	2.50	3.76	5.00
200	2.70	4.50	6.76	9.00

TYPE "C" FUSIBLE, TOP OR BOTTOM

30	70	1.06	1.60	2.12
60	1.18	1.80	2.70	3.60
100	2.38	3.66	5.50	7.30
200	4.40	6.76	10.14	13.50

Discounts:	
Less than $10.00 list value	15%
$10 to $25 list value	net list
$25 to $50 list value	5%
$50 to $200 list value	20%
$200 list value or over	25%